United States Court of Appeals

for the Second Circuit

APPENDIX

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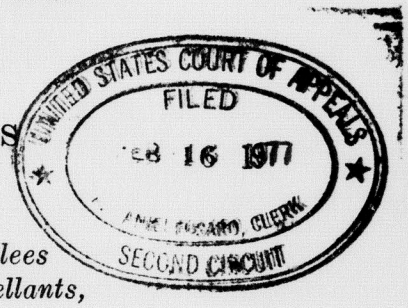
United States Court of Appeals
For the Second Circuit



EUTECTIC CORPORATION, NEW METALS CORPORATION and METALLIZING COMPANY OF AMERICA, INC.,

Plaintiffs-Appellees and Cross-Appellants,

v.

METCO, INC.,

Defendant-Appellant and Cross-Appellee.

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VOLUME IV OF EIGHT VOLUMES

(TESTIMONY — Pages JA769 to JA1098)

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BY MR. SPRUNG:

Q Now, would you like to proceed with your analysis of these references?

A Well, yes, for one thing I would directly like to comment on that earlier problem with respect to the accuracy

of Exhibit IL.

They state in that that their results, and they are referring to Oelsen, are more exothermic then selected values by 400 to 2,000 calories per gram atom. The more exothermic result is attributed by Kubaschewski to the presence of oxygen and nitrogen impurities.

Now, I went back to and have here that very reference by Kubaschewski in which he commented on the accuracy.

And I might say that it is a little bit like a story traveling from one person to another person to another person because the context gets changed.

Kubaschewski in commenting on Oelsen said that the present results -- and I am quoting now -- excuse me -- I am quoting now from Exhibit IW which is transactions in the Faraday society, which is the reference referred to from Exhibit IL. And it is an article by Kubaschewski. And he says --

MR. CALIMAFDE: Are these newly presented exhibits?

MR. KRAMER: You received the exhibits.

MR. CALIMAFDE: You are referring now to exhibits which have not been identified previously.

MR. SPRUNG: You were given copies of that.

MR. CALIMAFDE: When?

MR. GORDON: I can't find them.

MR. SPRUNG: Well, can we just finish this?

THE COURT: Yes.

THE WITNESS: I am quoting Kubaschewski Exhibit IW:

"Present results are numerically lower than --"

THE COURT: What page?

THE WITNESS: I am sorry. Page 815. And it is the bottom of the paragraph on that page labeled "results." It is about the second half.

"The present results are numerically lower than Oelsen and Middel by 10 percent --"

THE COURT: Do you find that?

MR. CALIMAFDE: No.

THE COURT: Do you want to use this (indicating)?

THE WITNESS: "Present results are numerically lower than Oelsen and Middels by 10 percent or less."

That is just within the claimed accuracy of Oelsen and Middels.

And he goes into that with that method,

referring to Oelsen, some oxidation is likely to occur, and so on.

What he is saying here is that it is a 10 percent error and not a 2,000 calorie error. So at maximum if we are talking about 3,000 calories per gram atom we are talking about a maximum plus a minus 300 calories.

BY MR. SPRUNG:

Q Now, do you consider, according to your own personal opinion in the flame spray field, the amount of heat reported as generated by reacting about three and a half percent aluminum with nickel as being realistic?

A Yes.

Q Would you explain why?

A Well, some discussion of whether the Oelsen method has some oxygen in it, and certainly in flame spraying there is some oxygen present.

Q So you would consider the amount of heat reported in the original article as being accurate for flame spray purposes?

A I think it is a good guideline.

* * *

THE COURT: All right.

Q Dr. Ingham, I would like you to refer to the 515 patent, column three, beginning on line 50, where it states, "While the components are preferably present in stoichiometric proportions required for the formation of the intermetallic compound, it is, however, possible to also have an excess of one or the other, provided the relative amounts are sufficient to release the quantities of heat indicated above in the formation of the intermetallic compounds."

Now, according to your understanding, what are the components referred to there in that portion?

A Well, the components are the components disclosed in the patent. These are metals which may react, exothermically, and it would particularly refer to nickel and aluminum.

Q Now, what are the relative proportions according to your understanding of the nickel and aluminum

in order to release the quantity of heat indicated?

A The proportions would be any proportions that would release more than this 3,000 calories and that would correspond to -- be on the nickel-rich side. That would correspond to about 3 1/2%.

Q By the weight?

A By the weight.

Q Now, have you ever made or had made under your supervision a nickel aluminum flame spray powder containing that low a quantity of aluminum --

A Yes.

Q -- in relation to the nickel?

A Yes.

Q And have you had such a composite flame spray?

A Yes.

Q Now, would you tell us how the bonding characteristics and the characteristics of the coating compare to those reported in example 31 of the 515 patent?

A Well, such materials give results quite comparable to those of example 31, bonding and coating characteristics.

Q Now, do you know if there has been any practice in the flame spray field by others to refer to alloys of nickel and aluminum containing 5% or less than 5% aluminum as nickel-aluminides or metallic compounds of nickel

and aluminum?

A Well, I'm aware of Avco selling a powder which is to be pre-reacted nickel aluminide, and it's called nickel aluminide. That is to contain 58 aluminum.

Q I refer to Defendant's Exhibit KO.

Is that what you're referring to?

A I said Avco. This is Bay State Abrasive which has been a subsidiary of Avco. Bay State Abrasive has this container selling their number 66, and it says nickel aluminide 95.

THE COURT: Now, you're referring to KO, is it?

THE WITNESS: Exhibit KO.

* * *

Q Dr. Ingham, have you sprayed coatings with Metco 404 material?

A This has been done for me, yes.

Q Have you sprayed coatings with Metco 450 material?

A Yes.

Q Have you sprayed coatings with the Exotec material?

A Yes.

Q Have you sprayed coatings with the Xuperbond material?

A Yes.

Q How do these coatings compare to each other and the coatings as described in examples 1 and 31 of the patent?

A Well, they are all very comparable to each other in general.

Q What common characteristics do they have?

A They all self-bond with a relatively high bond strenth. They all are relative oxidation resistant. Those are the general comparisons.

Q Have you sprayed coatings with plain nickel,

not in the form --

A Yes.

Q -- of a composite with aluminum?

A Yes.

Q And how do the coatings compare to the coatings of Codep 1, Codep 41, 404, 450, Excoco and Superbond?

A PLain nickel is not self-bonding.

Q How do the other characteristics compare?

A The oxidation characteristics for instance?

Q Yes.

A Nickel is not as -- as oxidation resistant as nickel aluminide.

Q When you say nickel aluminide you're referring to the coatings that I --

A Those other coatings that you referred to.

Q Now, according to your understanding of the patent, what's the primary purpose of the coatings obtained as described in the patent?

A The primary purpose is for bonding.

Q Now, in a material that is used for bonding do the wear resistance qualities of the coating count for much?

A No, they are of secondary importance.

Q Why is that?

A That's because an overcoat is put over the bonding coat and the details of the bonding coat don't play any role in what the overcoat is to perform.

* * *

Q Dr. Ingham, in accordance with your understanding of the 515 and 248 patent, is there any indication in these patents as to whether or not oxidation may occur when the materials are flame sprayed as described in the patent?

A Oxidation of materials during spraying is -- is a common, in fact a constant occurance, and the patent recognizes that.

Q Could you point out where it recognizes it?

A Column 4 in the area starting around line 31 where it speaks of adding a hydride to the material in order to suppress oxidation. That's what it says on line 33. So -- and then line 37, "Also for the purpose of reducing oxidation a metal hydride may be added."

Q Now, examples 1 and 31, did they disclose the use of a hydride?

A No.

Q According to your understanding would some degree of oxidation occur when following those examples?

A Yes.

Q According to your experience in the flame spray field what would you consider, if there is such a thing, a normal degree of oxidation as occurs in

flame spraying?

A Well, it would be commonly expected by those involved in flame spraying to expect about -- around 5% by weight. That might be somewhat more by volume.

Q And how much oxidation would you expect in accordance with examples 1 or 31?

A I would expect a similar amount of oxidation.

(Continued on the next page.)

BY MR. SPRUNG:

Q Now, in accordance with your understanding of the patent, what is this oxidation of, and referring again to column 4, 33 to 35?

A The oxidation of the metal components and the final sprayed products.

Q Now, with this normally expected oxidation would you expect or would you not expect to find aluminum oxides in the final coating?

A I would expect to find aluminum oxide in the final coating.

Q According to your experience do you generally find metal oxides of the materials being sprayed in the final coatings?

A Yes, this is commonly found in the sprayed coatings.

Q Now I refer you to column 6, beginning on line 6 through line 12 of the 515 patent. What is your understanding of that statement?

A Well, with respect to oxidation this statement --

Q I'm referring now to column --

A Well, column 6 line 6: "In combining in the exothermic reaction intermetallic compound the components generate heat in situ, and the actual material which is to form at least part of the coating. This is to be distinguished

from flame spray processes and materials where heat is generated by a reaction such as an oxidation reaction in which a foreign and non-metallic element is introduced."

Now, I -- I said yesterday that that refers to the thermic (THERMIT) type of reaction, the oxidation -- the non-metallic element of oxygen would be introduced in the form of another oxide. It would be in the composite flame spray material in the form of an oxide such as iron oxide.

Q That is solid material?

A A solid material. And the type of reaction they are talking about here in this portion of the patent would be the oxidation reaction in which a metal such as aluminum would react possibly during spraying with that iron oxide. This is not referred to the normal oxidation that occurs when any flame spray metal is flame sprayed.

Q Dr. Ingham, referring to the disclosure of the 248 patent -- and I'm asking you to ignore the claims at this time -- how does the disclosure compare with that of the 515 patent?

A The disclosures are the same.

Q Now referring to the 248 patent, it refers to conventional flame spraying. Now, what is your understanding that occurs when you practice flame spraying as described in the 248 patent; in other words, do you get any different or

unexpected results that you would normally expect to get in flame spraying?

A In the 248 patent the results that are obtained are a new bonding situation.

Q Does Metco to your knowledge manufacture self-bonding flame spray materials in accordance with the patents in suit?

A Yes.

Q Would you define these materials for the Court?

A Well, I really went into that a little while ago. I could -- I could go into it again. There are basically --

Q Just give us the designations again for the record?

A All right, Metco 450, which is similar to example 31; Metco 405 wire, which is similar to example 32(a); and Metco 404, which is similar to example 1.

Q Have you examined the accused powders involved in this law suit?

A Yes.

Q And I'm referring now to the Exotec powder, the Moldo M-55 and Xuperbond powder?

A Yes.

Q Now, based on your examination of these powders, how do these powders -- let's take the Exotec and Moldo M-55

powder; how do these compare to the Metco 450 powder?

A These are substantially just like Metco 450 powder.

Q Now, have you examined the Xuperbond powder?

A Yes.

Q And what is your understanding of the Xuperbond powder and how it compares to any of Metco's powders?

A The Xuperbond powder was very much like 450 and the Exotec ~~155~~. When cross-sectioned and looked at under a metallographic microscope under the right lighting there was some foreign material in the cladding, and by separating out the cladding material into its constituents and dissolving away the aluminum from it, getting a chemical analysis, we found that that constituent contained chromium and lead, and determined it to be a ceramic, and concluded that it was lead chromate that was added in the core, estimated around 1 percent or so, roughly, of additional material to the core. That was the only difference that I could ascertain.

Q You say chromate. What type of chromate?

A Lead chromate.

Q Do you have any understanding what lead chromate is?

A Lead chromate is a pigment used primarily in the paint industry, and as a coloring material. It's a ceramic-type material.

Q Now I hand you exhibit KT, and ask you is this a report of your analysis of the Xuperbond powder?

A Yes, KT is the report I wrote with respect to the Xuperbond analysis.

Q To the best of your belief that's an accurate report?

A Yes.

Q Have you analyzed the Duratec powder?

A Yes. Yes, I've analyzed Duratec powder.

Q And what is your understanding as to what the Duratec powder is or consists of?

A I understand that it is a self-fluxing alloyed powder which has blended into it about 10 percent of the Exotec powder.

Q Now, according to your understanding is the Exotec powder a flame spray material?

A Yes.

Q Is it in the form of a composite?

A Yes.

Q Is it in the form of a composite as defined in the 515 and the 248 patents?

A Yes.

Q Now, according to your understanding does or does not the 515 patent teach the use of the composite, nickel-aluminum composite powders, in accordance with the invention in add mixture with other flame spray powders?

A Oh yes, yes, the -- in column 6 line 25: "The composites in accordance with the invention may be sprayed in conjunction with or in addition to other flame spray materials conventionally used in the art."

Q Now, does it give any amounts, relative amounts as to the nickel-aluminum composites and the other flame spray materials?

A In line 36 it says: "In general as little as 10 percent by weight of the composites in accordance with the invention will be sufficient." So --

Q Now, from your study of the Durotec powder would you compare it with that description in the patent?

A The Durotec powder would fit directly with this 10 percent in add mixture with other flame spray material that's conventionally used.

Q Now, you testified that the Xuperbond material contained lead chromate coloring material. According to your understanding, what is the purpose of this material or what function does it serve?

A I don't know what good function it would serve, other than to color it a slight green color. It actually -- the Xuperbond tends to smoke a little more when it's flame sprayed, and that seems to be the general effect.

Q Have you ever sprayed the Xuperbond material and compared its bonding characteristics with the Exotec and the Metco 450?

A Yes, we found the bond strength of the Xuperbond to be somewhat less than the 450 and the Exotec.

Q Substantially less?

A Yes. I would have some numbers --

Q Do you have any understanding or belief as to why the bond strength in the Xuperbond would be less than the Metco 450 and the Exotec material?

A Well, I believe that additive is reducing the degree of reaction of the aluminum and nickel, interfering with reducing the effect --

Q Is the Xuperbond still a self-bonding material?

A It is still well up in the bond strength range that it would be a self-bonding material, yes.

Q Now will you describe for the Court the bond strength test that you conducted on Metco 450, Exotec and Xuperbond?

MR. SPRUNG: And I would like to call the

Court's attention that these tests were noticed as inter-party tests.

THE COURT: Which one is that, which exhibit?

MR. SPRUNG: I refer to exhibits KD, KC, KD-1 and KD-2.

Q Would you just describe these tests as briefly as you can, so that the Court will get an understanding of what is done, without being too technical?

A All right, on the day of the inter-party tests, which was --

MR. CALIMAFDE: I beg your pardon. I wouldn't characterize it as an inter-party test. I don't believe anyone from Eutectic was present, although we were invited. In any event these are tests you conducted.

MR. SPRUNG: They are inter-party tests. They were noticed.

If they don't choose to attend, that's their problem, your Honor.

* * *

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MR. SPRUNG: This is Exhibit KC, your Honor.

THE COURT: Mine has five, by the way.

THE WITNESS: I am sorry.

THE COURT: Maybe the first is a cover sheet.

THE WITNESS: Well, they are numbered 00629, 30, and 31 --

THE COURT: Yes. Which one are you referring to?

THE WITNESS. I am referring to all of them.

These were tests that were set up under as carefully controlled conditions as we could make practical, taking our thermospray gun, which is designated Model type 5P, which was chosen because of

its relative reliability, with respect to reproducing conditions from time to time during the course of the spraying that day.

The cover sheet on this, the one that is 00629, lists the general spray parameter conditions that were chosen for each of these tests.

Now, there are three materials listed. There is Metco 450. There was the Exotec and the Xuper Bond, each of which was handed to me that day, by Mr. Sprung and we broke the seal.

MR. SPRUNG: Your Honor, those powders were supplied to us by the plaintiff.

MR. CALIMAFDE: Not all --

MR. SPRUNG: I am sorry, the Exotec and Xuper Bond.

THE WITNESS: The 450 was taken from a standard container of produced material -- production material.

Now, for these bond tests -- bond tests are run by spraying onto the blunt end of shaft, and a coating of a certain minimum thickness is built up and then another shaft is glued to the coating. And then it is pulled in tension at an increasing rate of load until they break.

And the breaking point is known as the bond strength.

Q Now, would you summarize very quickly the results obtained by you in these tests comparing Metco 450, exothermic and Xuperbond with respect to bonding characteristics

A All right. The bond strength of Metco 450 were -- of the three samples -- within several hundred PSI's of each other, and averaging about 5,000 PSI bond strength for the three Exotec coatings, with just about the same bond strength for Xuperbond. The three samples were also very close to each other but ranged from 3500 to 3880.

Q Now, I notice that these values, let us say the 5000, are quite higher than the values we have been hearing during this trial. Can you explain that?

A Well, the exact spray conditions of the day would influence that.

Also these coatings were actually tested without an additional overcoat. In other words the bond coat material was built up to the proper thickness instead of taking a second step overcoat.

Much of the published information that is used for application purposes --

Q When you say "application purposes" what do you mean?

A The user would be interested in this coating because it has overcoats on it.

So most published information refers to another overcoat put over the bonding material.

And in these cases failure tends to be at an interface

with the bonding material and the overcoat material, or sometimes even up in the overcoat material and that is still reported as bonding strength, but tends to be a lower figure.

Q Dr. Ingham, in making these tests you used a Metco P gun?

A In these tests we used the P gun for this particular series of tests.

Q That is, so to speak, the top of the line that you have powder spray?

A Yes, powder spray line, yes.

Q Well, tell me why didn't you use for these tests the Rototec gun?

A We felt we could get better uniformity spray parameters that day from powder. We were trying to be as uniform as possible.

Q Well, have you ever personally sprayed an Exotec material or had an Exotec material sprayed under your supervision with a Rototec gun to obtain a coating?

A Oh, yes, I have had a number of coatings sprayed for me of Exotec with the Rototec gun. For example exhibit LF was done that way.

Q Now, Dr. Ingham, would you explain, in accordance with your understanding, what occurs when either Exotec or Metco 450 or Xuperbond is flame sprayed, and I

refer to a chart which I am marking MK.

(Article referred to was received and marked defendant's exhibit MK.)

THE WITNESS: Maybe I had better get over there.

THE COURT: You had better. There is a pointer if you wish to use it.

THE WITNESS: Well, I think the question was with regard to this exhibit MK -- was with regard to my understanding of what takes place when any of these particles -- powder particles of 450 or Exotec are fed into the flame.

Q And also Xuperbond?

A And also Xuperbond.

MR. CALIMAFDE: Will you establish the foundation for the knowledge which this witness is about to relate.

MR. SPRUNG: Your Honor, Dr. Grant has never seen flame spraying and testified to what he felt happened.

MR. CALIMAFDE: I'm not asking what Dr. Grant did or did not say. What is the foundation? Is it based on movies, or is it based on his theory, or just what is it based on.

MR. SPRUNG: It is based on his understanding from various experiences that he has had in the flame spray field.

THE COURT: Well, I think perhaps plaintiff's counsel is entitled to the witness' own statement illustrating your summary to some extent.

Do you want some voir dire at this time to establish ---

MR. CALIMAFDE: Well, I don't want to interfere or interrupt and waste time.

Your Honor, perhaps the fastest way is for this man to go ahead and explain his understanding of what occurs, and under cross-examination I will take care of it.

THE COURT: All right.

MR. CALIMAFDE: Thank you, sir.

THE COURT: Go ahead.

THE WITNESS: All right, this is what I visualize to be the case based on my being exposed to flame spraying and studying this situation.

Now, number 1, this first particle I had drawn to look like a cross-section of the 450 or

Xuperbond (indicating).

In other words, it is even before it goes into the gun, and is a core of nickel with a cladding of aluminum particles bonded to the surface with the resin liner --

THE COURT: No, let me ask you something there. You depict linearly what you say is the appearance --

THE WITNESS: Cross-section.

THE COURT: All right, or a composite of matter.

THE WITNESS: Yes.

THE COURT: Now, is that based on any -- what do you call it, an electromicroscopic --

THE WITNESS: Yes, this is based directly on any of a number of photo-micrographic pictures.

THE COURT: All right, so we will call that an illustration, illustration 1, which is based on really photo-micro --

THE WITNESS: Photo-micrographs.

THE COURT: Of.

THE WITNESS: Of cross-sections of 450 or Exotec, Xuperbond, whether made by ourselves or those I have seen submitted on behalf of Eutectic.

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THE COURT: All right. Okay. I have that now. And then?

THE WITNESS: So that is the starting point --

THE COURT: Right.

THE WITNESS: The starting point is something you can see under your microscope.

THE WITNESS: When you say below 660, that is below the melting point of the aluminum?

THE WITNESS: I am now talking about feeding this into a flame and visualizing what may be happening as the powder particle enters the flame, and then as it is being heated up.

What I am speaking of here is approximately the sort of progression of melting and reacting that would take place as the particle travels along and gets hotter and hotter.

THE COURT: In other words, if the 660 C is what you would consider the entry point --

THE WITNESS: The entry condition.

THE COURT: The entry condition.

THE WITNESS: Well, I say below.

THE COURT: That is before it enters --

THE WITNESS: Room temperature --

THE COURT: -- the flame.

THE WITNESS: Yes.

THE COURT: All right.

When it first enters the flame, then it meets temperatures of 600?

THE WITNESS: Well, it is seeing flame temperatures of much higher, 5 to 6,000.

But this refers to the temperature of the particle. And the reason I picked 660 is because it is the melting point of aluminum.

So before the particule is up to the lowest melting point of either of the constituents it will continue to have solid particles.

THE COURT: All right, I get that.

THE WITNESS: Now, what I haven't shown here but would like to explain is that there is resin there that we have all been talking about, holding those particles on.

THE COURT: In other words, what you are saying is that even these photomicrographs

do not show the resin?

THE WITNESS: No.

THE COURT: All right. Go ahead.

THE WITNESS: Now, during this stage of heat-up, I visualize that the resin is burning off and decomposing.

But this is a very short time period we are talking about. Times of particles in the flame total a few thousands of a second.

Now, this resin burning off and decomposing is going to protect this aluminum from oxidation, and it will specially be burning off in the outside portions first. And the resin on the inside will be the last to disappear, will be continuing to hold those particles on the nickel surface.

Then it reaches the melting point of the aluminum, this particle reaches that melting point, and the aluminum then can melt and can spread out onto the nickel surface.

* * *

THE WITNESS: No, I am sorry. The resin would burn relatively cleanly. Smoke would be produced -- if oxidation of the metal

particles are going on, they would produce smoke. That is based on extensive experience in flame spraying metal particles of various sizes. Under most conditions, there is a substantial amount of smoke generated during spraying.

And in the case of 450 or Exotec type of powders, the smoke is very low. In fact, earlier when you were asking about the differences between wire spray and powder spray, one of the reasons which powder spray is cleaner is the use of this type of material because it has less smoke.

That is a very real observation, that the smoke would be burning metal particles, if it existed.

And that smoke does not exist in this case. And so I deduce that it is being protected from oxidation.

It is also relatively well known that aluminum does not ignite and burn in air until somewhat higher temperatures than 660. So that is another reason that I am able to deduce that it is not burning at this stage.

THE COURT: All right.

THE WITNESS: Now, that takes us to this point where the aluminum has melted around the outside of the particles. If that occurs, then, according to all of the understanding of the reaction of nickel and aluminum, if you take molten aluminum with nickel, you are going to get the exothermic combination reaction, because that is where I have taken it to the next step and drawn in a reaction zone between the aluminum and nickel where nickel aluminides of some sort are being formed.

And in that zone, the heat would be quite extensive, since we are talking about relatively smaller proportions of aluminum and nickel.

So locally the calories per gram atom might be 8,000, 10,000, 14,000 calories, because of this concentration.

Now, eventually, and I just take it quickly through the next sequence of events, where the particle progesses into full melting and eventual distribution of the reactive material more uniformly throughout the entire

particle.

THE COURT: Now, that outer covering in illustration 3, what is that?

THE WITNESS: That is still the aluminum.

THE COURT: Still the aluminum?

THE WITNESS: In other words, what I have said here in this narrow temperature range, is that the aluminum is beginning to react at the interface where there is contact between the aluminum and nickel.

THE COURT: And that thin double line?

THE WITNESS: Called the reaction point where there would be nickel aluminides.

THE COURT: And is that what you referred to or what the patent refers to as the intermetallic?

THE WITNESS: That would be intermetallic.

THE COURT: Formation so to speak?

THE WITNESS: Yes.

THE COURT: So you have in effect, a merger of the aluminum and the nickel in what you call the reaction zone which is the intermetallic formation spoken of?

THE WITNESS: Yes.

* * *

A We keep speaking of the heat being generated, and the -- I am left-handed so I don't know if they can see. The amount of heat according to the amount of aluminum present, or since most of the pictures are in terms of the amount of nickel, this is on this side zero aluminum -- the amount of heat is just linear.

Q Dr. Ingham, would you explain the base line a little more carefully. That's the amount of aluminum in relation to what?

A This is the amount of aluminum -- this would be 100 percent aluminum, or conversely we have zero nickel over here and 100 percent nickel here.

Now, those are atomic percents for the sake of this discussion.

Q What are they?

A Atomic percents.

Q Could you do them in weight percents?

A All right, weight percents. Let me -- atomic percent is a little more logical for the diagram and then I will point out what is weight percent.

Q Okay.

A Because atomic percent, the amount of heat that you get as you add more and more aluminum increases linearly and in direct proportion to the amount of aluminum, up to a peak and then drops back down again. And that peak is quite close to 50 percent of both.

What this kind of chart means is that for each little increment of aluminum you add you get that much more heat.

Q Starting at zero percent aluminum?

A Starting at zero, and for our ten percent atomic percent, which corresponds to about five weight percent, the amount of heat is about 3700 calories per gram at ohm.

Q Would you write that on.

THE COURT: That's 10 --

THE WITNESS: I have ten atomic percent, five weight percent.

THE COURT: Oh, I see.

THE WITNESS: The reason I drew the curve in the first place is it's related more to atomic percent, peaking in the middle at 50 or near 50, and the 3700 calories is what corresponds to that weight percent.

MR. SPRUNG: Would you mark that MM.

THE COURT: Has anyone determined what the calories would be at the peak?

THE WITNESS: Yes, this is based on published literature.

Q What would the heat be?

A That's around 15,000.

MR. SPRUNG: May we mark this MM.

THE WITNESS: This kind of a chart is based on the number of points that people have measured for quite a variety of different percentages.

MR. SPRUNG: Mike, mike.

THE CLERK: One chart marked Defendant's MM.

(So marked.)

BY MR. SPRUNG:

Q Dr. Ingham, we have heard reference made to heat of solution as compared to heat of reaction in forming intermetallic compounds with respect to reaction between nickel and aluminum.

Would you explain your understanding as to whether there is such a difference?

A My understanding is if any aluminum is melted into nickel it is a reaction. The concept of solution is one of a lot less heat and does not apply to this case.

If there was solution going on without a reaction then this amount of heat would be very low, and then if it

reached some point where some kindof reaction did occur then it would start going up.

The curve would not be a straight line like this if there was a difference between a solution heat and a reaction heat in this case.

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DIRECT EXAMINATION

BY MR. SPRUNG (Cont'd):

Q Would you point out on this chart which you have made where, at what per cent, aluminum A, or what we call stoichiometric nickel aluminide might occur?

A Well, there are different stoichiometric --

Q Well just one, pick the first percentage point.

A The Ni^3Al is at 25 atomic per cent.

Q Does the heat --

A That would be here.

Q Why don't you write that in on the chart?

Does the heat increment by the reaction between nickel and aluminum change in any manner as you pass that point?

A There -- there is -- there is essentially no change in the increase in heat as we enter into this stoichiometric Ni^3Al area.

Q Suppose we add three weight per cent of aluminum and react it with nickel, so it is at a point between the point you marked, 3700, and the zero per cent aluminum; is that reaction in accordance with your understanding one which forms an intermetallic compound?

A Yes, it would be an intermetallic compound here at

three per cent.

Q All right, doctor.

Now, doctor, referring to Exhibit MK and point Box No. 6, where you have the particle molten, is that the form that the particle is when it strikes the base or substrate to form a coating?

A I would consider that the particle is either at condition 6 or possible at condition 5.

Q Now, according to your observation in spraying these materials, they self-bond when they strike the substrate?

A Yes.

Q Is it your opinion that it is the heat that is caused between the exothermic reaction between the nickel and aluminum which solely accounts for this bonding?

A It can't be the heat by itself.

Q What, according to your understanding, is it, then?

A I don't understand what it is.

Q Is it something special between the nickel and aluminum or --

A It must be related to the reaction possibly still going on as it is hitting, but it was heat alone, heat alone is something that we can and have put in by spraying

hotter, and that does not cause self-bonding.

Q Well, how about oxidation of aluminum; according to your experience will that aid in self-bonding a flame spray material?

A No. For instance, aluminum itself has been sprayed for many years and it is not self-bonding, not considered a self-bonding material. In fact, it is well known that it requires special -- a specially good surface preparation such as grit blasting in order to get a good, well bonded coating of aluminum, so aluminum does not adhere well.

If we spray aluminum hotter so that it burns more, that's very obvious -- it is very obvious that it is burning more when you do spray it hotter because you can see the smoke and the flame and that does not improve the situation.

Q From your experience in flame spraying can you tell in spraying aluminum or aluminum-containing material when aluminum is burning or oxidizing?

A You can certainly see the smoke going in.

Q And that burning phenomena, to your experience, does it or doesn't it aid in bonding?

A Generally it is a detriment.

Q Now, have you ever conducted any tests in which you flame sprayed particles and caused them to

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heat or get hotter by an oxidation reaction and determined whether they were self-bonding?

A Well, we have taken a number of materials and made them very similar to Metco 450; in other words, taken another material besides nickel and clad aluminum particles on, and tried that to see whether it would aid in bonding or cause self-bonding of the -- of the material.

We have taken -- we've done a number of different ones.

Q Would you describe for the Court some of those tests? I might refer to Exhibits KU, KV and KE-9.

THE COURT: Are those in your exhibit books? No, I guess not.

MR. SPRUNG: These are physical, Judge.

Q I refer to KU first.

THE COURT: What material is that?

THE WITNESS: Let me start actually with KW. KW is aluminum powder.

THE COURT: Just plain --

THE WITNESS: Just plain aluminum powder. It's a product we sell. It's sized --size distribution approximately according to the size of, let's say, Metco 450. And what we did was to spray that on to a panel and then spray

on a -- we sprayed on about five mils thickness and then spray on an overcoat of steel to see whether it would have any action in bonding the steel, and the coating started pulling off -- it looks like about 10 mils thick of steel started to pull off this aluminum.

BY MR. SPRUNG:

Q What bond strength would that be if it started to pull off at 10 mils?

A That would be zero bond strength because we wouldn't be able to put 15 mils on to run the test.

Q Now, would you describe your next test?

A The next test is that same aluminum powder clad with the same kind of real fine aluminum powder that is used to clad the Metco 450.

THE COURT: In other words, two different sizes; is that it? You are talking about two different sizes of aluminum powder?

WITNESS: ~~THE COURT~~: Yes, the KW was sprayed with the product that we sell as a flame spray aluminum powder. That is size plus 325 measure. Whereas now I am talking about cladding it with the powder that we use to make the 450 powder with. That's very much finer than 325 mesh.

BY MR. SPRUNG:

Q Dr. Ingham, is the second sample that you are just referring to, is that a composite?

A That is a composite.

THE COURT: Now, when you say "clad," you mean using the same kind of binder?

THE WITNESS: Yes, using the method in Column 5 of Example 31 and using the same procedure.

Q Would you explain to his Honor the structure of this particle in relation to Number 1?

A Well, this would look about like Number 1.

Q Except that would be the statistics?

A Except it would be an aluminum core and aluminum on the outside.

Q That is KU?

A KU was sprayed with that clad powder. And then an effort to overcoat the steel again, and it gave about the same result as KW. In other words, the coating left --

Q I'm sorry, I didn't hear. What was it left at?

A KU gave about the same result as KW. In other words the coating lifted when we overc ted.

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BY MR. SPRUNG:

Q And what would be the bond strength of that material?

A That too would be a zero bond strength.

Q Would you describe your next test in relation to the -- I guess that's KV?

A KV was sprayed --

Q Would you explain what it was that was --

A -- with a powder made of nickel oxide as a core material clad with the very fine aluminum.

THE COURT: I see, nickel oxide is like a metal, is it?

THE WITNESS: Nickel oxide is -- it's an oxide metal -- no, it's a ceramic, really.

Q Can aluminum react --

A No.

Q -- with nickel oxide to form an intermetallic?

A Actually that would fall into the class of the thermit type of reaction. It is possible for aluminum and nickel oxide --

Q I said to form an intermetallic?

A No, not to form an intermetallic compound. Nickel oxide is not a metal and there is no intermetallic compound formed.

THE COURT: All right, so that's nickel oxide core, is that correct?

THE WITNESS: That is correct.

THE COURT: Clad with the same fine powder that you previously described?

THE WITNESS: Right. I might say that in each case we were cladding by -- to give the same volume per portion of aluminum to the core as we would get in the 450, and that's not the same weight percent in each case, but it was designed to give the effective geometry.

THE COURT: Okay, now, what happened?

Q Will you tell us the result?

A The result was this barely adhered at all, and flaked off. We started to try -- what was there, we started to put some steel overcoat, and that immediately took it off.

Q When you use the words "it barely adhered," do you make a distinction between self-bonding and adhering?

A Well, adhering is not meant to be self-bonding at all in this situation.

Q And what is KE-9?

THE COURT: KE-9 did you say?

THE WITNESS: KE-9 is another powder intended to be a clad -- in this case aluminum clad

onto aluminum oxide. Now, there should be no combination at all there, no combination reaction of any sort, so if the aluminum was to do any good by burning that might have caused this to self-bond. But it did not. There was no adherence at all.

Q And what is your conclusion as based on these tests as to whether the clad aluminum in connection with the 450 or the Exotec oxidizes when sprayed or reacts with the aluminum when sprayed in order to form a self-bonding coat?

A Well, my conclusion is when we make efforts to clad a particle where there can be no intermetallic reaction, then we get no bonding, so I conclude that it must require that reaction to give us the bonding, and that the other possible mechanism, which is burning of that aluminum on the outside, does not occur.

And I might say that in spraying all of these clad powders that I've talked about, KU, KV, KW, KE-9, they smoked a lot when sprayed.

* * *

Q Now, Dr. Ingham, I believe you were present in Court when Dr. Grant testified as to his theory as what occurred when the Exotec or Metco 450 was sprayed with the separation of the aluminum particles on the outside of the nickel particles and their separate oxidation?

A Yes.

Q In your opinion is there a possibility that that occurs?

A No, I don't think that kind of situation can occur,

because of some of these experiences, not only from my past flame spraying but in these particular tests with cladding various powders with aluminum.

If aluminum was causing materials to be self-bonding by that mechanism, it should cause these others to be self-bonding.

And also I in each of these cases observed the smoke that's generated, whereas in the 450 type of material the smoke is very minimal.

Q Now what if we take a mere mixture -- have you done that, a mixture of aluminum powder and nickel powder, and spray it?

A Yes, I've done it.

Q What is the appearance when you spray that?

A It smokes quite heavily.

Q And that indicates what to you?

A It indicates that the aluminum is burning in the case of that mixture.

Q And is that material self-bonding?

A That material is not self-bonding.

Q Now, do you get this characteristic smoking of burning aluminum when you spray these composite particles which you made and in which the aluminum cannot react with the core material to form an intermetallic compound?

A Yes.

Q You do get them?

A Yes.

Q And you have observed that?

A I have observed that.

Q And do you observe this when you spray the normal 450 or Exotec?

A No. As I've been saying, the normal 450 and Exotec are notably low-smoke materials.

Q Now, you mentioned that aluminum -- I believe you testified in connection with exhibit MX -- has a different burning point temperature than the melting temperature of aluminum?

A Yes.

Q Would you explain that?

A Information on the burning of aluminum would indicate that the ignition temperature -- it is normally quite different from 660 degrees. And generally we observe this reaction to take place at the melting point of aluminum, which is the recognized reaction temperature for the reacting between nickel and aluminum for the intermetallic compound.

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Q I see.

What do you mean by ignition temperature?

A Well, ignition in this case would be the burning of aluminum in air. The ignition temperature would be that temperature at which that burning triggers, initiates.

Q Now, according to your opinion, if the self-bonding effect of the Exotec or 404 powder was caused by a burning or oxidation of the aluminum, could you get such a self-bonding if the spraying were effected in an atmosphere in which this oxidation could not occur?

A You would expect a reducted bond strength if you reduced the amount of oxidation.

Q Have you conducted any tests to determine whether or not that occurred.

A Well, these materials are routinely flame-sprayed with plasma spraying. We specifically ran a bond test for comparison a little while ago, and got a bond strength of 450 -- or it was this particular one with Exotec, sprayed in a plasma flame-spray gun, using Argon-hydrogen plasma to minimize the amount of air. The bond strength there was actually a little higher than the bond strength with the 5-P gun.

Q I hand you Exhibit KZ and ask you if that refers to the test you just testified about?

A That is not it.

MR. CALIMAFDE: Do we have that?

MR. SPRUNG: Yes, that's in the folder.

THE COURT: It is in the folder?

MR. SPRUNG: This we'll mark as KZ, then. Why don't I just have the Clerk mark that KZ?

THE COURT: Well, is that one already marked KZ?

MR. SPRUNG: This is the one we are going to offer, but we just put the sticker on the wrong paper.

THE COURT: Is that the right one to offer?

MR. SPRUNG: We are going to mark the right one now, and we will show it to you.

MR. GORDON: Will you give us a copy?

MR. KRAMER: Yes.

THE WITNESS: KZ is now the test that we ran on November 16. It was a controlled bond test, meaning we used the automatic work handling equipment, and sprayed onto three panels -- three bond specimens, using Exotec 29,904, with the plasma gun.

And the bond strengths there were about 5300 PSI.

Q And that is a good self-bonding material?

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A Yes.

Q Sprayed in the absence of oxygen?

A Yes.

* * *

MR. SPRUNG: LD.

THE WITNESS: These are Exhibits LD, LA and LB. Actually, there should be one more sheet that corresponds to the spray parameters.

Well, we can fill that in.

These were tests made on several powders was Metco 450, which is the nickel clad with about five percent aluminum.

I had two other powders made up. One of these powders was the product known as AVCO PP-66, which has been the subject of earlier testimony --

THE COURT: PP-66?

THE WITNESS: PP-66. That is pre-reacted nickel aluminide, containing five percent aluminum.

Q Is that basically Exhibit KO?

A Yes, it would be this type of material, KO.

Q Was that formed into a composite?

A That was made into a composite by taking AVCO PP-66 and cladding it with about five percent aluminum.

The third powder that was used in this test was the product known as AVCO PP-69, known to be a pre-reacted nickel aluminide containing 20 percent aluminum.

Now, these were sprayed for bond tests much as the tests run on the 13th of November with automatic handling equipment and the 5 P gun, spraying three samples of each powder, and running the bond strength test.

Now, in this series of tests the results were that the Metco 450 gave bond strengths averaging about 3,000 PSI.

The aluminum clad AVCO PP-66 composite gave a bond strength averaging about 4300 PSI.

And the powder which was AVCO PP-69 clad with aluminum, about five percent, to form a composite powder, gave a bond strength averaging about oh, 1500 ~~PSC~~ PSI.

In other words, that last one was a substantially lower bond strength.

Q Would you explain to his Honor what in accordance with your understanding is the significance of these decreasing bond strengths with the 450 material composite made with P-66 and the corresponding composite made with P-69.

A I think the significance is that particularly with the AVCO PP-69 which already has 20 percent aluminum reacted into the nickel, tying up most of the nickel reaction, that there is less nickel remaining to react with the aluminum and therefore it shows this result of a much lower bond strength.

Q Now, if there was an oxidation reaction of the aluminum, would that result occur, in accordance with your opinion?

A No, it would not occur because the oxidation that

may occur if the aluminum particles are oxidizing or released to being oxidized they wouldn't know that that core material had some pre-reaction in it and should cause the AVCO PP-69 composite to give a high-bond strength. But, in fact, it did not give a high-bond strength.

Q Now, referring to the P-66 --

A PP.

Q -- P-66 material which you clad with the aluminum powder in the same manner that you coat the nickel, in accordance with making the 450, is that in accordance with your understanding a material made in accordance with the 515 patent?

A Yes. The AVCO PP-66 contains five percent aluminum in it.

And the patent recognizes that pre-alloyed powders may be used in the constituents.

I have --

Q Any pre-alloyed powder?

A Well, provided there is enough nickel to provide an effective reaction.

That is what is discussed in column 4 around line 12 where they are using iron as an example, iron containing alloyed nickel.

Generally, an alloy of nickel and iron must contain

at least about 12 percent nickel for this purpose. In other words, there must be enough nickel available to further exothermic reaction. And that is recognized in the patent.

Q Now, as to the P-69, does it have enough unreacted nickel to --

A Judging from these results, it does not have sufficient unreacted nickel to give sufficient bonding.

Q Do you mean to be left over to react with the aluminum?

A Yes.

* * *

Now, Dr. Ingham, I would like to read to you from Dr. Grant's cross-examination with reference to the Haglund patent, 2,943,951, and for the record, this appears on page 516 of the record, Grant, cross:

"Question: And does the patent indicate that a way of solving this problem is to flame-spray the molybdenum disilycide with aluminum, so that the aluminum may react with the silicone dioxide film, removing this film, and avoiding this problem of the particles not sticking together when they are flame-sprayed.

A Except it is broader than that.

Q Does it say that? We'll get into that.

A Yes.

Q And additionally, the aluminum, in doing this, does react with the silicone dioxide, is that correct?

A Yes.

Q Exothermically producing a little heat?

A Yes, sir.

And then there were some objections to characterizing the heat as a little heat, but that isn't pertinent to my question to you.

Are you in agreement with -- number one, are you familiar with the Haglund patent?

A Yes.

Q And are you in agreement with Dr. Grant's testimony that flame-spraying this material, the aluminum reacts with the silicone dioxide film on the molybdenum disilycide?

A I'm in agreement that it may react with the silicone dioxide, if the aluminum particles are in sufficient proximity to the silicone dioxide.

Q Well, in order to react, in order for the aluminum to react with the molybdenum disilycide -- that is, a silicone dioxide film -- would there have to be contact between the aluminum and this molybdenum disilycide particle?

A There should be some contact, yes.

Q I mean, in order for a reaction?

A In order for a reaction, there has to be contact at some place, such as in the flame. Particularly in the flame.

Q Now, is there anything in the Haglund patent which teaches a closer proximity of the aluminum to the molybdenum disilycide particles than are obtained between the aluminum and nickel oxide in the Exotec or 450 type material.

A Well, they have several examples here. One of them is Example 1, where an aluminum is combined with a binder and molydisilycide.

Q Well, there, would you have -- Let's just go -- There would you have closer contact?

A No, you wouldn't have any closer than what's here.

Q Is there any reason to assume that if you could get contact for reaction between the aluminum and the molybdenum disilycide you wouldn't get contact for reaction between the aluminum and nickel in the 450 or Exotec material?

A No, if you are going to get contact in this Haglund-type of material, and get a reaction, why, I should think that would be all the more reason to think that you would get contact and a reaction between aluminum and the nickel with respect to an aluminum-clad nickel powder.

MR. SPRUNG: I'm asking him to analyze the graph and the results, and see if he agrees with Dr. Grant's conclusions.

THE COURT: Go ahead. All right.

THE WITNESS: Well, I have studied this graph, or both graphs involved here, numbers 64 and 65, and I've heard the earlier testimony, and I've compared the two graphs with each other, I've looked at the data that is on the graphs, and I see no basis for concluding that this is an oxidation reaction causing the -- the reaction to occur on number 64, as distinct from that on 65.

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Q Would you give the reasons by which you drew these conclusions?

A Well, if you compare these two graphs carefully you find that the increase in temperature that occurs as a result of a reaction -- that that increase in temperature starts at the same temperature in both cases, which is the -- corresponds to the melting point of aluminum.

THE WITNESS: Now, it's been brought out in earlier testimony -- and I would tend to agree with the fact -- that burning of the aluminum, if it occurred at all, might create more heat than a reaction between an aluminum and nickel. So that if this was a burning condition, the amount of heat generated by burning would cause this peak to go even higher than the Metco 404 peak, if the exotec heating was caused by burning.

Finally, I heard some explanation earlier with regard to the height of the final line for Metco 404 being higher than that of exotec, and

I think that is merely because there was more heat generated for 404, and that drains off into the holding crucible and strikes a higher level temperature balance overall.

THE COURT: You're speaking of this --

THE WITNESS: I am speaking of this final line, yes.

THE COURT: The projection?

THE WITNESS: Yes. So that is my analysis of these curves.

Q Dr. Ingham, I refer to Plaintiff's Exhibit 71, which is a plot of the Metco 450 type of material. Did you study that graph?

A Yes, I looked at this graph with respect to -- particularly with respect to the exotec graph, which is Exhibit 64.

Now, these are supposed to be very similar materials, similar amounts of aluminum, similar construction.

THE COURT: Yes, what one is that again?

MR. SPRUNG: 71, your Honor.

THE WITNESS: This is 71.

THE COURT: Was that in the book or was it --

MR. SPRUNG: No, it isn't. This is the one the doctor produced when they requested it.

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THE COURT: I'm sure I must have a copy, but I don't know where it went to.

MR. SPRUNG: It wasn't in the original book.

THE WITNESS: Now, in spite of them being similar type materials, a careful comparison would indicate that twice as muchheat was generated by the 450 as the exotec, and that would lead me to be suspicious of the tests and consider, unless more tests were run to show consistency -- at this point I didn't consider it a consistent set of results.

Q Dr. Ingham, would you consider in your opinion this type of test the best type of test to run in order to determine whether an oxidation reaction as opposed to a nickel-aluminum reaction was occurring?

A Well, I don't know. The logical thing would be to run tests with oxygen present and oxygen not present.

Q Have you run such tests?

A I have run such tests.

Q Would you describe these tests?

A Well, I ran tests very similar to what Dr. Grant has submitted here, essentially the same type of data, plotted, and since I did it on a number of samples I thought it would be more logical to show it presented in a plot of a band, and that is an exhibit --

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Q Is this the band, exhibit ML?

A That is the one I'm talking about.

Q Would you describe the individual tests that you ran and how they are plotted on ML?

A I ran tests on different materials.

Q When you say different, would you define the materials?

A All right, the different materials are the Metco 450, the Exotec and the Xuperbond. And I ran those three under argon atmosphere.

Q What is an argon atmosphere?

A Argon atmosphere is an inert atmosphere, ~~including~~ ck air from the furnace.

Q In your opinion in an argon atmosphere could oxidation occur?

A Very, very little, because not only are there relatively little traces of oxygen that might be there, but here we further are expecting that there is the resin binder available to keep out whatever air got in.

Q And what was the next test you ran?

A The next test was in air, and I ran just one of them, and that one -- I ran 450 in air.

And then the final test, number 5, I ran Xuperbond in hydrogen. I used hydrogen as a further effort, in case

there was any question of air being in there hydrogen would be a reducing atmosphere to remove any possible air.

Then I -- I got -- plotted each one, got a bunch of lines. I have shown them all together, and said --

Q Could you explain from the exhibit -- maybe you can go there to the exhibit and point it out --

A I think I could do it from here. Just that -- all of the -- the points are lines generated by these tests fall within this -- these bands, and I consider in running several tests this way that the width of that band does represent the accuracy of the tests, and within that accuracy all of the results for the different materials under the different atmospheric conditions were essentially the same within that degree of accuracy.

The most important portion of that being the increase from the beginning and the peak temperature reached.

Q These results show that an exothermic reaction was occurring in all of the tests?

A It showed there was an exothermic reaction, because heat was generated to increase the temperature.

Q In your opinion could that reaction have been an oxidation reaction?

A No.

Q Why?

A Well, for the same reasons I was describing earlier, the same reason applied here, that the temperature started to go up, to the vicinity of the melting point of aluminum, and the rates were substantially the same, the temperature was substantially the same.

Q How about the argon and hydrogen test?

A And there was substantially the same result as far as the choice of atmosphere.

Q Could it have been oxidation?

A It would have been different if oxidation was doing something under the conditions where there was air.

Q Could oxidation have occurred in the hydrogen atmosphere, according to your opinion?

A No.

Q What type of reaction do you conclude was taking place as a result of these tests?

A I conclude that this is a reaction between the aluminum and nickel, exothermic reaction, creating nickel aluminide.

MR. SPRUNG: We offer exhibit ML, your Honor.

(Defendant's exhibit ML marked in evidence.)

Q Now I would like to show you plaintiff's exhibit 63-C and 63-B. Have you studied those?

A Yes, I've looked at these photo-micrographs or photographs. I understand these were reported to be scanning electron microscope pictures of Exotec type material.

Q Do they show anything different than you might expect that the clad particles also in the 515 patent would look like, made in accordance with example 1?

A Well, these would be example 31. These look like one would expect from making powders according to that example.

Q You would expect them to have that appearance?

A Packed aluminum around the nickel core. They are very nice pictures.

Q And would you expect in general clad powders made in accordance with the description on column 5 of the 515 patent to have the same or different appearance?

A Same appearance.

Q I show you example KN and ask you if you can identify that?

A KN is a photo-micrograph made at my direction of a powder -- made according to example 31, with 15 percent aluminum and it -- it -- aside from the extra quantity of aluminum it has about the same appearance as the other class of powders that we had been talking about. By the others, the Exotec and the 450.

* * *

DDS:pc take 2/2

Q Now, Dr. Ingham, in the third paragraph of that same page, it says:

"...according to Dr. Notec et al, reports one to two microseconds as a resident time for the particles in the flame..."

Are you familiar with that reference?

A Yes.

Q Does that report, to your knowledge, one to two microseconds in the flame --

THE COURT: What page is that, by the way?

MR. SPRUNG: Same page, the third paragraph.

THE COURT: The third paragraph.

THE WITNESS: That report says, "one to two m-seconds," the small letter M.

Q What does that mean?

A That means milliseconds and not microseconds.

Q What is the difference between a millisecond and a microsecond?

A Well, the factor of a thousand. The microsecond is one-thousandth of a second -- I am sorry -- of a millisecond -- a microsecond is one-millionth of a second -- that is the correction, and a millisecond is

one-thousandth of a second.

Q How much shorter is the actual time reported than that stated there?

A He is a thousand times shorter than actually exists.

I might say that he has -- that that is easily calculated by anyone that should be familiar with flame-spraying.

The particle velocities in a flame spray gun -- a number of people have measured it -- are of the order of hundreds of feet per second. And if you take that velocity and divide it into a typical spray distance of say 6 inches, half a foot, or a little bit more than that, then you can calculate right away that the time is one to two milliseconds and not microseconds.

You don't have to use a reference to write down that number.

One can proceed to this report --

* * *

Q Are you going to proceed with the report?

A Well, his comment on the bottom of page 3, observation number 2:

"...flame with the nickel powder was somewhat brighter than PP-66..." when he flame sprayed both.

I would go along with his observation only and not with his conclusion that it is due to more heat capacity.

I think it is simply due to the varying tendency of nickel to oxidize and burn in the flame a little more than P-66 would do.

P-66 has some aluminum in it which will help protect it from oxidation.

Well, let me go on.

I find that the microscope examination confusing in the comparison, conclusions are drawn with regard to the metallurgical structure. And if one is going to draw conclusions about metallurgical structure, one has to run control tests to compare with. And I do not see that degree

of detail here.

So I have relatively little comment on that area except there is not enough information for me to comment about.

I particularly think --I don't know what he would mean for instance, by heat affected alpha nickel particles at the top of page 5.

Under chemical analysis he is comparing two materials, spray 29904 and a material called by the number of Lot 165C.

165C is a powder he said he made of the aluminum clad onto the AVCO PT-66.

Now, the AVCO PT-66 is a core powder in this case, containing 5 percent aluminum already reacted into it.

These results would indicate that somehow the aluminum is entirely removed.

That powder would start off with 5 percent of aluminum in the core, another 5 percent on the cladding; that would leave 10 percent.

On the final coating he gets a measurement of less than one percent.

Now, there is no comparison, for instance, with a chemical analysis on spray PT-66 to see whether that aluminum was lost to any extent.

And I would tend to believe from this, as well as

other -- through the experience I have had with trying to get chemical analyses of small amounts of aluminum and nickel -- and small could be in the 5 to 10 percent range -- it is hard to measure.

And I think this would be some indication that something may be wrong with the measurements on down to bond strength.

He does obtain some bond strength between the 29904 and the 165C in directly comparable tests presumably, and that does correlate with my own results where aluminum clad PT-66 can be of good bond strength.

Q Does the lot 165C have a nickel core which could react and form an intermetallic compound with an aluminum cladding?

A Yes, that is according to the patent, alloid or reacted with some aluminum, but there is sufficient nickel to react further with the clad aluminum.

That is described as possibly within the patent.

I think that would cover most of the report.

Q Now, have you read the conclusions in the report, Dr. Ingham?

A Yes.

Q Do you agree with those conclusions?

A Well, I generally disagree with his conclusions. I think they are based on data and observations which can --

are either wrong, such as these measurements of particle separations, speeds, or are conclusions taken in the wrong direction from observations.

I did not -- For instance, conclusions 1 through 4, I do not see any basis in his report for concluding that way.

Q Dr. Ingham, have you attempted to spray a mere mixture of coarse aluminum powder and finely divided aluminum powder -- nickel powder?

THE COURT: I thought that was covered this morning?

MR. SPRUNG: No, this is not.

THE COURT: A mixture of coarse and fine aluminum?

MR. SPRUNG: Mr. Patel testified he couldn't spray this mixture in a rototec gun. I want to extablish that was done --

THE WITNESS: Well, after Mr. Patel's testimony --

MR. SPRUNG: Yes, all right, go ahead.

THE WITNESS: -- we had a day off. We went back and mixed nickel core powder with 5 percent aluminum powder, without any binder, and sprayed it with a rototec gun.

Now, it was difficult to spray. However,

it was possible to spray just by tapping the side of the gun, so we were able to try to get a coating with the rototec gun.

THE COURT: I am sorry. I missed something. I thought you said coarse aluminum --

MR. SPRUNG: I am sorry. I was correcting myself. Nickel.

THE WITNESS: The same constituents as 450 would be made out of.

THE COURT: Yes, I understand. I remember your saying this morning --

THE WITNESS: I did say it in another context.

THE COURT: Yes, I know that.

Well, Mr. Sprung said aluminum and aluminum.

All right, so you mixed the coarse nickel and fine aluminum powder and sprayed it in a rototec gun?

THE WITNESS: In a rototec gun.

And we have a panel here --

Q I refer to exhibits KY-1 and 2.

A KY-1 was what we were able to spray with the rototec gun by tapping the gun, while spraying, we were

able to get it to feed and to get a little coating. I had an overcoat with steel to some extent and it lifted off at some 10 mills thickness.

Q What would be the bond strength.

A I wouldn't be a measurable bond strength.

Q What is K-2?

A K-2 was a repeat, only using the N gun with which we had no problem feeding it.

And the powder again produced a coating.

We put an overcoat on and that lifted, indicating no bond strength.

Q That is KY-2?

A Yes, KY-2. That is what I was just referring to.

MR. SPRUNG: May we have the panels that Mr. Patel sprayed (addressing Mr. Calimafde.)

Plaintiff's exhibit 77.

MR. GORDON: It may take some time.

Q Did you examine the panel which Mr. Patel reported he sprayed using his blend containing the secret ingredient?

A Yes.

Q Is there anything you noted about that?

THE COURT: What is the exhibit number?

MR. SPRUNG: The exhibit number of the

secret ingredient is plaintiff's exhibit 77.

We do not have the panel that was sprayed with it.

THE COURT: I see.

THE WITNESS: Let's wait for the panel.

BY MR. SPRUNG:

Q I would like to show you defendant's exhibit KS, KT, KQ, which I believe are all specimens that Mr. Patel testified that he sprayed during his test.

Is there anything you can note about those?

(continued on the next page.)

DDS:p
take 14

A Well, these have been over-heated.

Q How do you know that?

A You can tell from the blue color. That is an indication that the panels have been heated at least to 5 or 600 degrees.

Q Would you compare that with some of your own sprayed examples?

A Well, we were careful not to overheat. And these panels don't have that blue color.

Q What could this overheating of base do?

A Well, it can affect the bonding. In some cases, for instance, if there is free aluminum present, it might cause the aluminum to stay on better.

Q It would be like a fusion?

A Possibly we think it is through the thermic type of reaction where when the iron oxidized, the aluminum can then react with the iron oxide.

Q Now, I would like to refer to defendant's exhibit K, which is the Handbook for Users put out by the plaintiff for the Rototec process, and would refer you specifically to the sixth page of that booklet.

Do you find any instructions concerning overheating and how it is detected?

A Well, it is recognized, and I certainly would

recommend to the industry not to heat the substrate up to such temperatures. And cooling procedures for the work piece such as blowing air at it or stopping periodically to allow the panel to cool off, those procedures are normally used.

Indeed, this particular document is a Rototec document, part of what is called the Handbook for Users. It is exhibit FK. And on page 59642 --

THE COURT: 2 or 3?

THE WITNESS: 2.

A (continuing) -- Eutectic recommends that the temperature be kept below 500 degrees.

And it has in big letters here: "Remember, if heat tinting or discoloration occurs, the workpiece is being unnecessarily heated and improperly Roto-coated."

Q Now, the panels which you just examined, are KP, KQ, and KS heat tinted?

A These are heat tinted. It shows that the panels went substantially above that 500 degrees.

Q Now, I refer to defendant's exhibit KR and plaintiff's exhibit 78 which are -- KR being an agglomerate of particles of aluminum, agglomerated with aluminum powdar, and plaintiff's exhibit 78 being a blend of 5 percent aluminum with 95 percent nickel, do you note any heat tinting

on those panels?

A These are both heat-tinted quite substantially.

And in both cases, free aluminum would be present and one would expect that high temperature to change the results of any bonding tests that were being run.

Q Now, Dr. Ingham, have you studied the prior art references which have been introduced as exhibits in this matter?

A Yes, I have.

Q Now, based on your study, do any of these prior patents or literature references disclose a self-bonding material?

A None of these apply to self-bonding materials.

None of these disclose material or teach a material which is effective as a self-bonding material.

Q I refer you to United States Patent 2,588,421, which has been noticed by the plaintiff, but has not been referred to during this trial.

Does that relate to self-bonding material?

A That's Shepard?

Q Yes.

A That refers to a self-bonding material.

Q What material is that?

A The Shepard patent is one that refers to a self-bonding

material and that refers to the molybdenum wire.

Q Now, Doctor, in accordance with your opinion --

THE COURT: Is that patent in Shepard?

MR. SPRUNG: The Shepard patent was cited by the plaintiff, but I do not believe they put in specific testimony as to it.

THE COURT: Well, may I say --

MR. CALIMAFDE: That patent has not been cited by us, your Honor.

MR. SPRUNG: Well, it was put in your 282 notice.

THE COURT: Well, we agree it is not in here.

MR. SPRUNG: Well, we will introduce it then as our own exhibit.

MR. KRAMER: JC.

MR. SPRUNG: Why don't you put a tag on it?

Will you mark this?

THE CLERK: Defendant's exhibit JC for identification, United States Patent Office patented March 11, 1952.

And it is JC for identification.

(So marked.)

Q Now, have you studied this Shepard patent?

A I am familiar with it, yes.

Q What does it disclose as to self-bonding material?

A This discloses molybdenum --

MR. CALIMAFDE: Your Honor, since we are not relying on the patent, I really don't understand its relevancy.

Why discuss patents which are not cited as part of the prior art?

MR. SPRUNG: We are showing invalidity. We can show that there is no similarity in characteristics between the only previously known self-bonding material and this new self-bonding material.

***

Q Now, do the nickel aluminum composites in

accordance with the 515 and 248 patents have any similarity in structure or features to molybdenum wire?

A They have nothing in common. Molybdenum is a refractory type of material and it has no similarity other than being metallic with nickel and aluminum, or with nickel aluminides, or with any exothermic reaction concept that might occur between nickel and aluminum.

Q Now, I would like you to refer to the Gutzeit et al patent, which is2,908,589.

A Yes.

Q Would you tell us very, very briefly, what that patent relates to?

(continued on the next page.)

DDS:pc
Cake

A Well, this is the utilization of a waste product from a chemical plating bath and that product consists essentially of nickel phosphorus material.

Q What is a nickel phosphorus material?

A A nickel phosphorus material is what is referred to as an amorphus material. It is essentially nickel with some 10 percent or so phosphorus. And that phosphorus is in that nickel as individual atoms dispersed in the nickel.

Q Is the nickel phosphorus material a composite according to your understanding?

A It is not a composite because phosphorus atoms are dispersed individually as atoms within the nickel. And phosphorus is not there in any separately physical form such as a composite would refer to.

Q Now, were, to your knowledge, nickel phosphorus materials such as nickel phosphorus alloys known in flame spraying?

MR. CALIMAFDE: When?

MR. SPRUNG: Prior to 1960.

A I don't know of it.

Q Do you know that they are known today?

A I do not know of them being flame sprayed materials commercially.

Q I am not talking of the Gutzeit material itself,

but I am talking about the use of nickel phosphorus alloys.

A Nickel phosphorus is used or has been used on occasion, although not extensively that I know of, but it has been used as a self-fluxing alloy type of combination.

Q Has it ever been used as a self-bonding material?

A No, it has not ever been used as a self-bonding material.

Q I will read to you column 7 beginning on line 15 of the patent.

What is your understanding of that statement?

A Well, this is the statement starting about line 15 on column 7:

The nickel phosphorus alloy of the coating is very advantageous in that it has a relatively low melting point normally in the range 880 to 950 degrees C.

And the phosphorus content thereof acts as a de-oxidizing agents resulting in the capability of the molten droplets or globules to wet most metals even though they are coated with a thin unwettable oxide film.

That is a description of a self-fluxing alloy.

Q Does that, according to your understanding, have anything to do with self-bonding characteristics?

A No.

Q Now, I would refer you to column 6 line 7 where it says, "...whereby it adheres thereto forming a

coherent coating thereon..."

A Well, they are talking about "adhering." And that word "adheres" shows up in the literature, in the patent literature quite frequently. And take it in that entire context does not mean self-bonding at all.

Q Now, is, according to your understanding, phosphorus a metal?

A No.

Q Now, have you had any experience spraying the material as described in the Gutzeit patent?

A Yes, we obtained some material, and this is the kind of material described in the patent as has been discussed at earlier testimony, particularly related to an accompanying article that was cited and refers to nickel plating material from the Kanigen process. It is a commonly known process.

And we contacted nickel platers and obtained some of the waste material, as the Gutzeit patent teaches should be done. And we crushed that up and attempted to spray it.

MR. SPRUNG: Now, your Honor, I would like to refer to a notice given of inter-party tests which was dated November 6, 1973, and which should be in the record of the case.

We say:

"Please take notice that on the 13th day

of November, 1973, the defendant will conduct a series of tests and experiments the subject matter of which they plan to introduce into evidence in the above-captioned case at its main offices and plant at Westbury, New York.

"You are invited to attend."

BY MR. SPRUNG:

Q Now, was this spraying of the Gutzeit material conducted at this inter-party test?

A Yes.

Q Now, I hand you exhibit KA and KB and ask you if you can identify those?

A KA is the receipt when we obtained the Kanigen type of material.

KB is a technical bulletin received at the same time which discusses the material received and refers to it as Kanigen.

MR. SPRUNG: That technical bulletin was marked with the name of the Keystone Metal Finishers Inc.

I believe that appears on the back.

THE COURT: What is it that is on the back of the book?

MR. SPRUNG: Keystone Finishers, Inc.

THE WITNESS: That is where we obtained this receipt for --

MR. SPRUNG: And I would like to say for the record that we supplied an example of the material as we obtained it and powder to plaintiff.

THE WITNESS: This bulletin also refers to the General American Transportation Corporation which is the company that the Gutzeit patent is assigned to.

Q Would you describe during these inter-party tests, the spraying of this material? What occurred?

A Yes. As I say, we crushed up the powder and screened it to the size described in the patent and sprayed it onto smooth ground panels in order to look for any self-bonding properties.

Q Well, did you note self-bonding properties?

A No.

Exhibit KE-1 is a result of one effort where we made passes back and forth. There is only a small fraction of the panel that has any coating stuck to it.

Q What is KE-4?

A KE-4 is the same material sprayed on a grit-blasted surface, that is, a surface prepared in the normal roughing manner, and that it did achieve a coat.

MR. CALIMAFDE: I didn't hear that.

(Record read.)

Q I refer to KE-3. What was that?

A KE-3 was another sample sprayed onto a smooth ground steel -- I mean it was another panel smooth ground steel that we sprayed onto and then in order to test it as a self-bonding material, overcoated with steel, and the steel lifted with a very thin coating of steel.

(continued on the next page.)

Q Would you say the bond strength was, in the Kanigen material, made in accordance with the Gutzeit?

A It ranges from not even possible to get it to stick to patches which have zero bond strength.

MR. CALIMAFDE: What was that?

THE WITNESS: To zero bond strength panels. To portions of panels that might have some stuck to it.

MR. CALIMAFDE: I thought I heard him say that one did stick.

THE COURT: You heard that earlier.

THE WITNESS: Yes.

THE COURT: KE-4 grit-blasted surface did achieve a coating. I think that is what you were referring to.

BY MR. SPRUNG:

Q Would you compare, based upon your study of the Gutzeit patent, your experiences with the material, that material and its flame-spraying with the material of the 515 patent?

A Well, this Gutzeit material is not a composite. It is not formed of two metals and it is not self-bonding.

Q Is there anything in the Gutzeit patent which relates to nickel and aluminum?

A There is nothing whatsoever. It refers only to nickel and phosphorus.

Q Now, I would like you to turn to the Bradstreet patents 2,904,449 -- well, before I turn to the Bradstreet, let's assume that when you sprayed the Gutzeit material, heat was generated during the spraying, would that aid in bonding?

A It didn't.

Q All right, returning now to the Bradstreet patent, would you tell us again as briefly and as distinctly as you can, what that patent discloses?

A Well, the Bradstreet patent concerns spraying of oxides which are ceramic materials.

And it gets into some discussion of how you raise the temperature of the flame in order to better spray oxide materials, since these are what they call refractory oxides and have a fairly high melting point.

So that is the basic trend of the patent.

Q Are you familiar with the flame spraying of refractory oxides such as aluminum oxide?

A Yes, these are in flame spray materials.

Q Are they self -bonding?

A They are not self-bonding.

Q Are there bonding characteristics?

A They bond relatively poorly.

Ceramics must have a good, a very good surface preparation in terms of roughening. But actually, very commonly, a metal is put on underneath, particularly a self-bonding material.

Q Now, is there anything taught in the Bradstreet patent that -- which could make these refractory oxides self-bonding materials?

A There is nothing in here which can make them self-bonding or which even gets into the subject.

Q Now, during these inter-party tests, have you prepared and sprayed any Bradstreet type materials?

A This carries a little deeper into the Bradstreet patent.

In regard to the teaching of the patent to increase the temperature of the flame, they speak in column 4 -- excuse me -- column 5, in and around paragraph 36 and on:

"Still another technique which is effective to raise the temperature of the particles of the flame is that of adding a material to the composition which will undergo an exothermic reaction while in the flame.

Specifically certain metals can be added to the final divided form of the oxides or sources of oxides injected into the flame. And such metals will undergo an oxidation which effectively raises the temperature of the particles in the flame. Particularly preferred for this use is aluminum

powder which becomes oxidized."

And on line 48 or so, it speaks of 5 to 7 percent of the composition.

Now, I had several combinations tried in order to test out anything that might be in Bradstreet for self-bonding.

Q Would you describe what material is set forth in this portion you just read?

A This was sprayed on --

Q Well, tell what was sprayed.

A This is KE-8. Exhibit KE-8.

I made up a blend of standard aluminum oxide flame sprayed powder. It happened to be our product METCO 101.

I made a blend with 7 percent of aluminum such as is suggested on line 48.

And sprayed that. And this panel is the result.

This is Exhibit KE-8.

We took one pass, that peeled right off. While we were making a second pass, more material went down underneath the first pass.

Q What is the bonding strength of that?

A That is zero bond strength. It is just a film of the coating falling off at this point.

Q Now, spraying this material, did you notice

anything?

A There was smoke generated through the burning of the aluminum.

Q Did you you notice that when the exothermic material or METCO 450 is sprayed --

A No. That differs in the degree of smoke. This is much more.

Q Now, I would like to refer you to the Haglund patent 2,943,951.

Would you again, as briefly and as precisely as you can, summarize your understanding of this disclosure in that patent?

A All right. This patent discusses the use of molybdenum disilicide which inherently has on it, due to exposure to the atmosphem, a film of silicon dioxide.

And this patent discloses adding aluminum to that powder in such a way that they want the aluminum to react with the silicon dioxide film.

Now, that would be the kind of reaction I had spoken of earlier, with respect to iron oxide, for example, where the aluminum reduces or itself becomes oxidized by the oxygen that is available from the silicon dioxide.

That silicon dioxide is there in a solid form.

(continued on the next page.)

Q Now, is there anything in this patent that the material is or might be self-bonding?

A There is no indication in this patent with regard to that kind of bonding. The closest it comes is speaking of sintering together of the particles.

Q What is sticking together of the particles?

A That's sintering together of the particles, is the particles with each other building up the coating, as distinct from any combination of the particles with the substrate material.

Q Now, have you been during these interparty tests, tested the Haglund material?

A We made up a powder, I might say with some difficulty, according to example 2, following as closely as we could the teaching of the patent and that example. The only exception was that we did not have the material known as TASI 2 that's on line 50 of column two, that these should be in there in three percent.

The patent teaches chromium silicide as another altnerative so we substituted 3% of chromium disilicide.

We compacted the powder mixture and sintered it in an atmosphere of hydrogen at 1200 degrees C and then crushed it up and screened it and then sprayed it on the day of those tests.

Q And what were the results?

A In several sets of tests none of the powders or none of the powder was self-bonding. I might say that they teach a minum 325 measure powder. We sprayed that and it didn't self-bond, just --

Q That's Exhibit KE?

A KE-6.

Q What's the bond strength of that material?

A Zero.

Q And what other form did you --

A Well, we also, since that didn't seem to me to be a logical size to use here, produced a coarser powder and sprayed it, and it gave similar results: No bonding.

Q Zero bond?

A Zero bond. Also, since this powder was smoking rather violently under the conditions that we were using, which was the Metco end gun, we switched to our 5P gun, which has the versatility of -- of allowing the cooler flame, using hydrogen gas for fuel -- that's not as high temperature flame and is commonly used for spraying aluminum -- with that set of parimeters we sprayed this Haglund powder and again got zero bonding.

Q Did at any time you make a material as described in example 1 of the Haglund patent?

A Yes, we made up a material as described in example 1. That's by taking the several statistics, blending into a powder and then blending with Polyethelene and extruding into a wire-type form.

We did not run this the day of the

Q I give you Exhibit LH. What is that?

A LH is a piece of the wire that we made up. I might say that it's gotten brittle. It was more flexible earlier.

Q And did you spray that material?

A Yes, this was the material sprayed.

Q And what was the bond strength?

A That provided zero bond too.

Q In your opinion, is there anything in the Haglund patent which could teach you how to make a self-bonding material or indicate to you how to make a self-bonding spray flame material?

A No, they don't teach in that direction and the materials from that patent don't show any signs of self-bonding.

Q Now, Haglund does teach, does it not, a composi of components which will exothermically react?

A Yes, that's the reaction between the aluminum and silicone dioxide.

Q And what would that lead you to conclude

with respect to bonding and the features of composite form and exothermically reacting form?

A Well, this would show in conjunction with the rest of the picture that exothermic reaction isn't by itself what causes self-bonding.

Q Now, I would like you to turn to the Montgomery patent, which is United States patent 2,775,501, and would you again give us a very brief and concise description of your understanding of the disclosure of that patent?

A This involves a material for flame spraying which they call a ceramic metal -- that is it would be a composite powder, each composite particle made up of a metal and a metal oxide, the metal oxide being a ceramic again.

And the whole patent is just based on spraying ceramic-metal type materials.

Q Now, have you any familiarity in the flame spray field with ceramic-metal materials?

A Yes.

Q According to your knowledge and understanding are these materials self-bonding?

A They are not self-bonding.

Q Is there anything in the Montgomery patent which indicates a self-bonding material or how to make such a material?

A I would say the contrary, since they refer to preparing the substrate, column 2, line 29 and 30, "We prefer very much that the surface to be coated should be sandblasted before applying the coating."

And that would describe to people spraying that one should provide the rough surface for a bond, and there is no other teaching in this patent that this material bonds.

Q Now, I refer to column 3 at about line 43, where it refers to a powder weld oxyacytelene powder gun. Are you familiar with that type of equipment?

A Powder weld type gun refers to the process of spraying and heating the coating and work piece to a high temperature in order to fuse it.

Q Now I refer to column 4, beginning on line 27, "Adherence of the coating."

A Yes.

Q What does thatindicate to you?

A Well, in reference to the use of the powder weld gun that would mean they are fusing the coating.

Q And I refer to column 5, beginning on line 15.

A Well, again at line 15 "Just enough heat is used to alloy given coating to a given metallic base," and their method of spraying again at line six is with the

powder weld gun.

Q What does that indicate to you?

A Again that is spraying and heating enough to fuse. And also in spite of that there is at lines 7 and so on, "The metal surface to be flame sprayed was cleaned and roughened by ~~great~~ blasting, to use -- using a sharp and fairly coarse silica sand or silicone carbide grit."

Q Now, have you conducted any tests spraying the Montgomery type zero metal?

A Not recently. We have experience with these kinds of materials. We did do one that was a variation of this, where we clad some aluminum on to aluminum oxide and sprayed that. That was --

Q Is aluminum on aluminum oxide a ceramic metal?

A Aluminum on aluminum oxide would be a ceramic metal. Our -- that would -- could be made by the cladding method, according to the 515 patent.

Q And was this sprayed during the inter-party tests?

A Yes.

Q And what was the result?

A The result was a coating. We overcoated or started to overcoat with steel to see what was there, and it

immediately lifted off. That would amount to a zero bond, strength? And that's Defendant's Exhibit KE 7?

A KE 7.

Q Now, at this time did you also spray the Metco 450 material during the interparty tests?

A Yes, sprayed 450, which we have been doing routinely as a control, and that panel is KE 2. It has some steel overcoated to show that nothing is listed under the conditions in which all of these overcoats lifted.

MR. SPRUNG: That is KE 2.

Q Now, I refer to the Schwayder patent, which is 3,049,435, and would ask you again to give us a very brief and concise summary of your understanding of the disclosure of that patent?

A Schwayder describes a powder that may be used in flame spraying, that powder is a composite powder of tungsten carbide coated with nickel or what they call nickel nickel phosphide. And that powder is a powder which can be used for flame spraying.

The way this patent is direct it teaches to subsequently heat and the work piece -- subsequently or simultaneously heat and fuse.

Q Are you familiar with the type of tungsten carbide in flame spraying?

A Yes, powders of this type we investigated some years ago, and were not very satisfied with the results. We chose not to produce or sell a powder of this type.

Q Is this material self-bonding or does it have any self-bonding characteristics?

A It is not self-bonding to my knowledge. Also Avoo for a while marketed a powder of this type, and I haven't heard of it lately, I don't believe it was commercially successful.

Q Is tungsten carbide itself used in flame spraying as a flame spray material?

A Tungstein carbide is a very common material in flame spraying.

Q Is it a self-bonding material?

A No, not very well.

Q And how do they effect bonding of tungsten carbide?

A We effect it by mixing in withthis a self-bonding type of powder, and exothermic powder.

Q In accordance with the 515 patent?

A With the powder of the 515 patent type.

Q Now I would like you to refer to the Hensel et al patent, which is 2,370,242, and would you very briefly summarize that, the disclosure of that patent for us?

A Hensel involves powder but has nothing to do with flame spraying. It has to do with putting palladium, platinum or rhodium layers onto refractory metal powders such as tungsten and molybdenum. Here the platinum or so on are for the purpose apparently of protecting those refractory metal powders.

Q You say they are not for flame spraying?

A Nothing here says anything about flame spraying.

Q In your opinion, if this type of material were formed into a flame spray material would it be self-bonding?

A No. This patent also goes into the coating -- in order to produce their powder it goes into the coating of the core powders by first coating the powders with a disbursible adhesive then dusting the adhesive coated particles with the protective metals in powder form, and subsequently heating the coated powders.

I think this patent uses the terminology of referring to powders made with an adhesive material as coated powder.

(continued next page.)

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FL folno es

Q Now I'd like to refer you to the Bleakley patent, which is 2,231,247, and again give us a very brief and concise description of your understanding of its disclosure.

A This -- this patent involves flamespraying of a wire, a composite wire which is made up of copper sheath with lead in the middle, and specifically concerns copper and lead, or at least combinations which will not mix together -- copper and lead are examples of two metals which will not mix at all, known as immiscible or non-miscible. And the purpose of this patent appears to be to obtain a coating containing both materials, and obtaining it without the problem of -- that other methods might use or might get into because of this lack of this ability.

Copper and lead certainly do not exothermically react. Neither are self-bonding. The coating would be a mixture of both, and the coating of the combination would not be self-bonding.

Q But the spray material is a composite?

A The spray material is a composite.

Q Does the patent teach you anything as to the relationship between composite form and self-bonding characteristics?

A No.

Q Does it teach that there is or is not a rela-

A They don't get into it.

Q Now I would like to refer you to both the Gralar and Herz patents, which are 2,910,346 and 2,884,688, and maybe for the sake of brevity you could treat both of these patents together.

Tell us basically what your understanding of the disclosure of these patents is.

A Well, they both concern nickel and aluminum. Neither of them concerns flamespraying and they are both concerned with making nickel aluminide or nickel-aluminum alloys. And they apparently exist because there are problems with the exothermic reaction, and each patent goes its own way in teaching how to solve the problems of forming the alloys in spite of the problems of the reaction.

Those are the gists of those patents.

Q Would these patents indicate to you anything which you might use in determining how to form a nickel aluminide coating in flamespraying?

A No, neither -- well, the closest it comes is one of them happens to have as an intermediate step the existence of some powder, which is subsequently compacted. Possibly that could be concerned. But that is not the thought here at all.

Q Well, having these patents in front of you,

as one skilled in the art would you consider attempting to make the nickel aluminide in situ during flamespraying, or would you from the teaching of the patents pre-react the materials?

A These patents to pre-react, because they would indicate that there are problems with reaction and that one should avoid or get around the reaction if possible.

Q Now, have you sprayed pre-reacted nickel aluminide powder?

A The PP 69 that you were talking about earlier would be the --

Q Is that self-bonding?

A No.

Q Now I'd like to refer you to the Mackiw patent, which is No. 2,853,403. And would you summarize for us your understanding of the disclosure of that patent.

A This is a patent covering a method of making powders. The method is the -- what's known as the Sherritt-Gordon process, where there is a chemical reduction in a bath, causing nickel to plate out onto, or nickel or a large number of other combinations -- a large number of other metals -- onto almost any core material.

Q From your study of the patent how many specific combinations are exemplified?

A They have --

Q Or are included?

A Well, you can count them here. They have indicated 35 core material and 13 possible plating materials. It multiplies to 455 combinations. So that there would be possibly 455 powders suggested.

Q Is there anything in this patent which would lead you to select from this 455 possible combinations the combination of nickel and aluminum?

A There is no trend at all in that direction.

Q Is there anything which would indicate that you should pick materials that might exothermically react?

A There is no indication of that.

Q Does the patent at all relate to a flamespray material?

A No.

* * *

aml04

DDS/elc

Q Well, you commented on the photomicrographs in your testimony yesterday, and you testified that these photographs were typical.

Now Mr. Patel testified,as you may recall, that these specimens were atypical. And he said in fact that as a result of looking at more than 100 photomicrographs, this represented less than one percent.

Now, do you have any photomicrographs of the

Exotec powder?

MR. SPRUNG: When you say, "have," do you mean with him?

A I have made --

Q Well, in this case.

A -- photomicrographs.

Q You have made them?

A I have had them made for me. I have seen them.

Q Of the Exotec powder?

A Yes.

Q And they have not been produced inthis case so far as you know?

A As far as I know.

Q In fact, as far as I understand the record as it is presently constituted, there is not a single photograph, photomicrograph, offered by Metco of the accused powder?

Am I correct? Are you aware of any photograph, photomicrograph, of the Exotec powder?

A I do not know for sure whether any has been submitted.

I have myself been relying on reports such as this and the general statement that 450 and Exotec were the same.

That statement, was, as I understood it, made by plaintiffs with regard to this case.

myself personally believed that from what I have seen of photomicrographs.

So that is what I have been relying on personally.

* * *

Q Well, we will discuss that in more detail later. We are going to the basis for that.

As I understand our record, the only photograph you have produced is of a 515 powder which is Defendant's Exhibit KN; is that correct?

A Yes.

Q If you look at the powder particle in the center, that seems to have perhaps much more than half free of any powder and perhaps one-third of some aluminum powder.

A The adjacent one is completely covered.

Q That is correct. We look at the one up there inyour picture and do you show a powder of a type of the right-hand particle or center particle or what?

What did you intend to show?

A I intended to show the nature of the reaction --

Q No, the left-hand one.

A I didn't intend to pick out any one particle.

Q This photograph, KN is of an 8515 powder, isn't it?

A Yes.

Q By 8515 we all understand --

THE COURT: What exhibit are you referring to, Mr. Calimafde, just the number.

MR. CALIMAFDE: KN.

Q Am I correct that your Exhibit KN is the only photograph offered by Metco in this lawsuit of any powder particle?

MR. SPRUNG: I object, again, your Honor. This is an expert witness and he doesn't know what was offered by his attorney.

THE COURT: Is there any dispute about it being the only photograph?

MR. SPRUNG: Just the implication, your Honor. Naturally, we would use their photograph if we agree with them.

THE COURT: I understand, but there is no other.

Is that correct?

MR. CALIMAFDE: As far as I know there is no other photograph offered by Metco of any powder except your Exhibit KN.

MR. SPRUNG: I don't know, your Honor.

We offered some of your exhibits, too.

THE COURT: Well, is KN your product or --

MR. CALIMAFDE: No, sir, it is no commercial product.

This is a photograph of a particle which consists of 85 per cent nickel and 15 per cent --

MR. SPRUNG: That is Example 31.

MR. CALIMAFDE: And 15 per cent aluminum corresponding to Example 31.

THE COURT: I see.

Q Are you familiar with pictures taken by scanning electron microscopes which give a perspective view of the surface of a powder particle?

A In a general way.

Q Did you examine these photographs which Eutectic produced of, from a scanning electron microscope showing in perspective the surface of a powder particle?

A I examined some. I don't know which one you are referring to.

Q You examined loads that were produced by Eutectic of the Exotec powder?

A Yes.

Q Now, here again as far as I understand the record, Metco has not produced a single picture taken by

a scanning electron micrscope of the Exotec powder.

Did you, or to your knowledge, anyone at Metco ever take a picture of the Exotec powder by a scanning electron microscope?

A Yes.

Q When.

A Several times during the last year.

Q Did you turn these over to your attorney?

A No.

Q Were they taken during the course of this lawsuit?

A Yes.

* * *

Q Did Metco to your knowledge ever make a picture of the elctron bombardment type such as 63-B of the Exotec powder?

A Not specifically of an Exotec powder.

* * *

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Q I am not interested in evidence. I am asking about tests, not speculative tests or experience or literature reading. I want to know what positive evidence in the form of a test or test data has been produced by Metco or anyone retained by Metco which would help us resolve this issue as to whether or not there is nickel-aluminide in the sprayed coating? What have you produced outside of Post's X-ray diffraction test?

A I don't believe we have a test, another test directly related in that matter.

* * *

Q If I understand your testimony, you did not obtain an X-ray diffraction report from the independent laboratory prior to trial, prior to the beginning of this trial; is that correct?

A That is correct.

Q Did you attempt to obtain a scanning electronic microscope analysis of Eutectic's flame spray powder prior to the institution of this trial?

A We considered micro-pictures in investigation and decided that would be exclusively with respect to that and did not look for nickel aluminide that way.

* * *

Q Did you make any attempt to calculate mathematically whether in fact the container could have or did absorb and retain the heat which was generated by the quantity of powder used by Dr. Grant in his calometric test?

A I didn't have the information to make a specific calculation. This upper level would be logical from such equipment.

Q You also commented yesterday when you were criticizing Patel's report that it would be difficult to obtain a chemical analysis of the coating to determine whether or not there was any nickel aluminide present; is that your testimony?

A Yes.

Q Did you at least try to obtain a chemical analysis?

A We had made some efforts sometime in the past to obtain chemical analyses.

Q When?

A A number of times through the years is all I particularly recall.

Q You had the Exotec powder available, you could have sprayed as much as you cared and you could have sent

as much of a quantity as you cared to form an analyses, why did you not do it, sir?

A By then my feeling was such an effort would not prove anything.

Q Yet, Mr. Patel obtained a chemical analysis of the spray coating and according to his chemical analysis there is no nickel aluminide present. Do you have any data, not speculation, but data, to refute Patel's chemical analysis?

A I have none at hand here other than the collective significance that I have had that such a chemical analysis is inaccurate.

* * *

Ingham - cross

Q And the post scan was conducted during the trial, is that correct?

A Yes.

* * *

Q From your own knowledge isn't it a fact that proper and effective bonding depends upon many conditions which must be carefully observed with regard to the spray gun and spraying conditions?

A Bonding, and the spray quality of the coatings does depend upon the choice of the spray conditions, yes.

Q Such as particle size?

A Such as particle size.

Q The relative particle size of the two components, if there are two components?

A Well, that gets into the structures of the powders for other purposes. We are talking about spray purposes.

Q I am talking about spray purposes to produce an effective spray coating. It also depends on the proportions of the components, does it?

A If there are several components then it must be taken into account.

Q The heat of the gun?

A Yes.

Q Of the velocity of the gases?

A Yes.

Q The mixture of the gases?

A Yes.

Q The spray distance?

A Yes.

Q And the speed at which the gun traverses the workpiece?

A Yes.

* * *

established a flame spraying distance, a flame heat, and these other parameters based on your 450 and you stayed with the same parameters when you tested the other powders?

A Based on 450 and nickel aluminoid.

Q Here I see 450 (indicating).

A That is No. 2 panel was 450.

Q Your No. 2 panel became your control for this particular test?

A Yes.

MR. SPRUNG: Define what you mean by control?

Q What does the word control mean in this field?

A In this particular case it means when we sprayed a material we were familiar with, not an experimental material, we took a number of passes on the panel, we obtained a thickness which was reasonable, we obtained a complete coverage, and a bonding which was expected.

Q So you established these conditions based on your 450 powder?

A I didn't establish any new conditions. We followed instructions, book conditions, in the "N" gun described for nickel and powders.

Q What I'm trying to understand is whether you varied any of the settings once you established it for the 450 powders and if so, where do I read on your pages about the new settings and new conditions?

A We did not vary conditions, we did not consider it necessary.

* * *

Q When you obtained that panel which is KE-1, which shows a partial coating, did it occur to you to vary some of the parameters of your flame spray to see if you could make more of it stick?

A Yes.

Q What did you do?

A I decided that was --

Q What did you do?

A I decided that was the most likely set of parameters to make it stick.

Q You didn't vary any of the parameters in regard to this nickel precipitate coating?

A Do we have more of my notes?

Q Yes.

A No, I have no different parameters.

* * *

Q In mixing this powder you indicate you followed the teachings of example 2 in the Haglund patent?

A The best we could.

Q You say the best you could; what does that mean? Do you have anywhere the composition you used in connection with example 2 in the proportion of the Molybdenum dicilicide with aluminum and a binder?

Perhaps it would be more orderly, Mr. Ingham, for me to refer to example 2 and let me ask you whether you mixed a composition containing these parts: For example, example 2 calls for a mixture of 90 percent Molybdenum

dicilicide. Did you obtain 90 percent of Molybdenum dicilicide?

A Yes.

Q From where?

A These are materials that we have in our lab for routine use. They are materials that we have on hand.

Q And Molybdenum dicilicide as such?

A Yes.

Q And example 2 also calls for 7 percent --

A There is an exception: I used aluminum rather than aluminum magnesium. I did not have on hand aluminum magnesium. Certainly within the teaching of this patent aluminum and magnesium are taught interchangeably.

Q Well, that's not my question, sir. This example 2 calls for 7 percent of an aluminum magnesium alloy in 50/50 percent proportions. You did not use that?

A I did not use that. I used aluminum.

Q 100 percent aluminum but in a 7 percent proportion to he total?

A Yes. And as I said yesterday, I -- I missed yesterday that I had substituted the aluminum for the aluminum magnesium. As I said yesterday, I did substitute chromium dicilicide for the tantallum dicilicide, since we did not have tantallum dicilicide.

* * *

Q Now let me ask you: Did you follow any example in Bradstreet?

A No, there was no example pertinent to what we were doing.

Q All right, Bradstreet KE-8 does not conform to any example in the Bradstreet patent, is that your testimony?

A It corresponds to the general teachings -- I will locate it -- I think I mentioned it yesterday in my testimony, the location in the patent which we were following.

Q May I ask why you didn't follow a specific example, since there are examples in Bradstreet?

A We were following the portion which came closest to describing specifically the addition of aluminum powder, particularly to aluminum oxide, and as I recall, the examples didn't come as close, and I felt that that would come closer to materials that -- of the sort that we are discussing in this entire case.

* * *

Q Now, on this date, November 13th, when you sprayed KE-8, Bradstreet, your testimony is you did not vary it from the 450 powder spraying parameters?

A That is correct.

* * *

DDSnext

Q Now, you have here also Montgomery but you don't have any data under the name Montgomery.

Did you perform a test for the Montgomery composition?

A This material, No. 7 --

THE COURT: Is that KE again?

MR. CALIMAFDE: KE 7.

A (Continuing) KE7 would also have reference to the Montgomery patent as well as for the Bradstreet patent.

Q So that you used the same composition 2017 with aluminum for both Montogomery and the Bradstreet tests, KE8 and KE7? Is that correct?

A No. KE8?

Q KE8 is Bradstreet.

A That is a blend and it only refers to the Bradstreet. The blend is not a cermet ~~thermit~~. It is a simple blend. The cermet ~~thermit~~ is a composite powder.

So KE8 can refer to the Bradstreet patent but not to the Montgomery patent, since the Montgomery patent refers to th CERMETS.

THE COURT: Well, then, what was the difference in the composition of that?

THE WITNESS: Now, KE7, aluminum clad -- is a clad aluminum oxide.

And I might say in all of these, to save some time, that in all of these aluminum clads the percentage used was a volume percent, would be the same as the aluminum clad on the nickel and 450 powder. And it is about 15 volume percent.

Q I thought you were trying to follow the example in the patent.

A In Montgomery I didn't follow any specific example.

In Montgomery I had a familiarity with spraying ~~thermits~~. And we didn't happen to have any on hand. And I felt strongly that --

Q That was not my question, sir, how strongly you felt. I am concerned about only what you did and not how strongly you felt.

With regard to Montgomery, which is KE7, do I understand you did not follow any example in the Montgomery patent?

A No.

* * *

Q Is that what you recommend at Metco, that a surface be grit blasted before spraying so-called self-bonding materials?

A Sometimes.

Q In fact, the article you wrote for MIT states that this good blasting produces a better bond, does it not?

A Yes.

Q Of course, you would always be interested in recommending to your customers how to produce the best bond possible?

A Right.

Q So it would follow that you would recommend a good blasting?

A Yes.

Q In fact, most of the examples in the patent

that mention preparation refer to good blasting?

A Yes.

* * *

4/2DShb

Ingham-cross

Q Will you turn to page 15, the last question and answer.

Did I not ask you the following question and did you not make the following answer:

"Question: Is this what may be referred to as a metallurgical bond between the coating and the substrate?

"Answer: I think the use of the word metallurgical bond has been a loose one. I don't think it serves any typical purpose as such. I think I would call it an alloyed layer.

"Question: Alloyed bond or alloyed layer between the substrate and a coating?

"Answer: Yes. Where we could see that that seemed because of the bond to do that or something. That was determined a number of years after the bonding..."

* * *

Q I asked you whether another expression for self-bonding was alloyed bonding.

A And I say no.

Q You say no.

Now, at this deposition did you not indicate that an alloyed bond was a self-bond?

A No.

Q You did not?

A No.

Q What is a self-bond?

A Self-bonding is an adherence, and this is in the flame spray industry, so we are talking about flame spray material. It is adherence of a flame spray material to a smooth,

clean metal surface.

And that adherence is strong enough to receive other material or be built up to thicknesses that are normally used with the material in their respective applications.

It is a concept of strong bonding and a concept of reliability and relatively little technique dependence in achieving it.

It is as broad -- as it has been accepted in the industry, a broad practical concept.

* * *

THE WITNESS: My deposition, the question starts further up on page 15:

"Question: Do you know what causes self-bonding?"

MR. CALIMAFDE: Excellent. Now read on.

Your Honor, that answers the question exactly on page 15.

THE WITNESS: What it is and what causes it need not be the same.

Q Let's read exactly what you said in the deposition at page 15.

The question was put to you: "Question: Do you know what causes self-bonding?"

And the answer: "Answer: We believe we know why this material, this nickel aluminum bonds.

"Question: Why?

"Answer: Because in the course of the work later on there was some investigations to see what was at the interface. And the metallurgists working on it were able to detect a layer which seemed to represent an alloying of the coating particle and the substrate. And we felt that that probably was the thing that caused the bond.

"Question: Is this what may be referred to as a metallurgical bond between a coating and the substrate?

"Answer: I think the use of the word metallurgical bond is a lose one. I do not think it serves any typical purpose. I think I would call it an alloyed layer."

A All right, that is entirely correct with respect to my view on the theory of why this adheres in the case of nickel aluminum.

But the alloy layer is not synonamous in my mind with the fact of a commercial concept or practical concept of the ability to put on thick layers.

* * *

DDS:ss
4PM3

Q I am asking whether the nickel aluminum so called self-bonding is self-bonding because of an alloying between the coating and the substrate?

A I believe that that is why nickel aluminum adheres.

Q And let us confine ourselves to nickel aluminum for a while. So that we do have an alloying and that alloying is a result of heat, is it not?

A Heat plays a role.

Q Well, when you talk about alloying aren't you talking about melting one metal in contact with another so they alloy with each other?

A Yes.

Q And in order to cause one of the materials to melt it requires heat, does it not?

A Heat plays a role, yes.

* * *

Q Is it first required that the aluminum nickel particle become molten?

A That is required.

Q Is it required that the nickel aluminum particle be in a molten or plastic state by the time it reaches the substrate?

A Just as any other metal.

MR. CALIMAFDE: That is not my question, sir.

THE WITNESS: Yes.

Q In the molten state, assuming the substrate

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is a compatible metal, will nickel aluminum particles alloy with the substrate metal?

A We believe the nickel aluminum will.

Q So that if I melt one into the other, will I produce an alloy layer between the two?

A Yes.

Q When we talk about it or we talke about a self-bonding coat, do you talk about an alloyingbetween the coating and the substrate?

A When we're talking about self-bonding, we're not particularly answering that. We have found in those two cases that there is the possibility of that alloy spot layers.

Q When you say possibility, hasn't you said that in connection with those materials, nickel aluminum powder, for example, there is an actual alloy with a substrate in very thin layers?

A Such a thing has been seen. I think there is even some question as to interpretation of the photo micrographs with regard to seeing those.

Q Why don't we see what you call it in your article you wrote for the MIT people.

* * *

os/LH
1PM (2)

Q Look at Page 310 at the left-hand column, the last paragraph which begins with "For most materials;" do you see that?

A Yes.

Q If you come to the second sentence in that last paragraph, beginning "Those materials that adhere;" you see that?

A Yes.

Q "Those materials that adhere to smooth surfaces and are used for bond-coat purposes, such as molybdenum, nickel aluminide, and a few others, actually alloy with the substrate in very thin layers."

A Yes.

Q Were you referring to the alloy resulting from the heat?

A I'm talking about the alloy that we've been talking about here.

Q Is that the alloy between the sprayed powder coating or the sprayed coating, rather, and the substrate?

A Yes.

Q It's an alloy which occurs in very thin layers?

A Yes.

Q That's an interaction between the coating and the substrate, is it not?

A Well, it's some kind of mixing or reaction. We don't know the details.

Q That results from heat, the heat applied to the powder?

A Well, heat would be one important factor.

* * *

THE COURT: Although, I realize now that alloy could also have been used in the sense of the melting together of the two different metals that form the composite. I assume that isn't

what we were really talking about, but we were talking about alloy meaning the, you might say, the second composite, so to speak, that is to say the composite of the two components with whatever metal or substance formed the upper layer of the substrate.

Do you understand me?

THE WITNESS: Yes.

THE COURT: Do you accept alloy in that term?

THE WITNESS: I accept alloy in the sense you have described.

THE COURT: That's what we are investigating here.

MR. CALIMAFDE: Yes.

THE COURT: Therefore, I want to know, has it been physically demonstrated that there is such an alloy relationship?

THE WITNESS: Yes, it's been physically demonstrated in those two specific instances that I was mentioning.

THE COURT: You mean the molybdenum and nickel aluminum?

THE WITNESS: Yes.

* * *

MR. CALIMAFDE: This report by Longo is Plaintiff's Exhibit 43 which is in the book.

I will refer --

Q Well, I will refer you to page 5 of his article. This is page 43 of page 5 (sic).

Have you read this article?

A Yes.

Q Under the heading bond layer, beginning, oh, about one-third of the way, it looks like the third sentence beginning with the word "apparently", substrate area; do you see that?

A Yes.

Q Immediately under a sprayed particle of the exothermically reacting nickel aluminum is heated sufficiently to melt and fuse with the nickel aluminide forming the alloy layer.

Now, do you agree with that statement?

A I agree that is the way he was explaining it.

Q That's not my question.

Do you agree with that statement as a technical matter not whether you agree he wrote it?

A I think that's an i complete statement.

Q So you don't agree with this statement technically?

A No, I don't.

Q He uses the word "fused," sufficiently to melt and fuse.

Is the word "fuse" an apt word in connection with the interaction between the coating and the substrate?

A I think that is the kind of word that would be used in this sense, yes.

Q Is the fused redundant over the word melt? Do they mean the same thing?

A Well, melt could be an individual situation, fuse implies an adherence together.

Q So that the fuse implies a so-called bonding or the alloy that we are talking about?

A Yes.

Q Now, on page 7 of this article, under the acknowledgement paragraph, there is : "The author wishes to thank Dr. Ingham for his stimulating comments on the text of this paper."

Are you the Dr. Ingham?

A Yes.

* * *

Q Are you familiar with this article written by Mr. Dittrich?

A Yes.

Q Pardon me?

A Yes, I haven't read it recently but I am aware of it.

Q Will you turn to page 493. Now, first in the box which contains a biographical sketch of the author --

A Yes.

Q -- the last sentence beginning with the words, "The actual development ..." Do you see that?

THE COURT: Where is that?

MR. CALIMAFDE: In the box, your Honor, on page 493.

THE COURT: Oh, yes.

Q The last sentence beginning with"the actual development." Do you see that?

A Yes.

Q The excellent development of a practical development of a spray powder had to wait for the new

technology to become available but once this occurred the new type of powder was possible.

Do you agree with that statement?

A In a general way. I don't know who wrote the statement.

* * *

THE COURT: I don't wish to engage in semantics with you, but I'm beginning to see why they may have used the carefully raised expression which aids in bonding. You know, self-bonding, to me as a layman, would mean that the nickel aluminide was the only thing we were talking about that did the bonding.

Now, it has been earlier demonstrated here that the bond that can't be viewed in terms of just the nickel and aluminum, but must be viewed in terms of the cooperation of the substrate and I could read that as meaning that what we have here is that which induces the cooperative action, so it isn't self-bonding, but rather that which aids in a union not otherwise achieved. So I don't know that I, in view of the fact that the claim reads the way it does, that I put the importance upon self-bonding or would feel it's that important in any event. And I think that

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in some way we may be chasing butterflies here.

Isn't it -- I guess from the time of the Hittites, we knew metals, different metals could be combined and would produce stronger metals, but that isn't the point of this, as I see it. This is the question of a union of a metal composite powder with another metal-like surface.

MR. CALIMAFDE: Substrate.

THE COURT: When we talk about self-bonding, they don't use it there. I consider it a real misnomer because it doesn't self-bond. It induces the cooperation that something else, that other materials in balance do not succeed in doing, if I understand Dr. Ingham's testimony.

* * *

Q What is the minmal bonding strength you would associate with self-bonding?

A Well, there is no specific minimum. The concept is more practical than it is an exact number and it encompasses

the reliability. In the case of plasma --

Q That was not my question. I asked you what is the minimum bonding strength associated with self-bonding.

A I am in the process of answering it.

Q I am not asking in connection with the plasma or thermo spray gun but in connection with self-bodning. I heard in direct examination in order for something to have the characteristic of self-bonding it must have the bonding strength of so much psi.

MR. SPRUNG: Whose direct examination?

MR. CALIMAFDE: Mr. Ingham's.

Q Do you recall giving that testimony?

A I don't recall giving any numbers.

Q I ask you whether there is a minimum?

A There is no exact minimum. With respect to the combustion process, 2000 psi has been used; with respect to plasma which is an area where more premium coatings are required, the minimums set forth by users tend to be higher.

* * *

go to 1932

Q Isn't it a fact that there is no example in the patent-in-suit, the 515 patent which describes a nickel aluminum composite having the proportionate of 95 to 5, 95 nickel and 5 aluminum?

A No specific example.

Q That is correct?

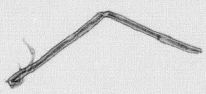
A Yes.

Q It is also a fact that the first example in the patent-in-suit is directed to the Metco 404 powder which

is the 80-20 proportionate composite 80 per cent nickel and 20 per cent aluminum?

A Right.

* * *



Q In fact, perhaps for clarity, Mr. Ingham, we can

refer to the total expression as the appearance in lines about 41 to 43, "any two metallics which may be melted together to form an inter-metallic compound in an exothermic reaction." So we are referring to an inter-metallic compound in an exothermic reaction, all right?

A That's what it says.

Q That's what it says. Do you find anywhere in this patent any reference to a heat of solution?

A I don't believe there is any reference to heat of solution in this patent.

Q Are there tables to your knowledge which show the thermal release from a heat of solution? Are there tables which show the thermal release or the energy release resulting from two metals going into solution?

MR. SPRUNG: Would you define the metals, or just any metals?

Q Any metals. Are there tables in the literature--

A Different metals from these, yes.

Q Now, when you say these you are referring to the 144 that appear in Table 1?

A I am referring specifically to nickel and aluminum.

Q Are the hundred -- I guess I've been saying 144 and should have said 142, if my arithmetic is correct. In Table 1 I have compiled 142 combinations. Are the

combinations which appear in Table 1 combinations of two metallics which may be melted together to form an inter-metallic compound in an exothermic reaction?

A That is what the table is supposed to be a listing of.

Q Now, when the expression thermic reaction is used, that means of course it generates heat, isn't that right?

A Yes.

Q So that these 142 combinations in Table 1 are of metals that will generate heat to form an inter-metallic -- when they form an inter-metallic compound, is that correct?

A Yes.

Q And when they generate heat that heat aids in binding between the material being sprayed and the surface upon which the coating is sprayed?

A Yes.

Q Now, isn't it also a fact that -- and I shall take the articles one at a time, let us start with the German article IV-1 -- isn't it a fact that in the article IV-1 there is no reference to a heat which results from an inter-metallic reaction?

A Well, as I see their data, it is plotted as a heat versus percentage aluminum.

Q Isn't that a heat of solution, sir --

A No.

Q (Continuing) -- that they are referring to in the article?

A No.

Q Does the expression in the German -- does the expression inter-metallic reaction appear in the German article?

A I don't recall just how they phrase it.

Q Now will you refer to page 13 of the German article, please. Do you see it?

A Yes.

Q The lower -- there are two charts on that page 13. The lower chart is presumably a nickel-- I said page 13, I should have said page 15. Page 13 has cobalt aluminum. It's page 15 that has the phase diagram for nickel aluminum.

Do you see it, the lower one on page 15?

A I see it.

Q Now, isn't it a fact that the phase diagram appearing in this German article has been discredited as a phase diagram for nickel aluminum?

A With explanations as to why.

Q Is the explanation to my question yes, that this is not considered to be the --

A The equilibrium phase -- this is not considered to be

the equilibrium phase diagram.

Q Which has been spoken of with authority by yourself and by Dr. Post and by Dr. Grant as the so-called phase or equilibrium diagram for nickel aluminum?

A Yes.

Q So the German article upon which you rely shows a nickel aluminum phase diagram which has been discredited, isn't that a fact?

A Details.

Q Yes. Now will you refer to the article by Kubaschewski, Exhibit IX. Do you have that, sir?

A Yes.

Q Did you read this article?

A Yes.

Q Isn't it a fact that Kubaschewski did not measure heat of solution of alpha nickel solid solution?

A That is correct.

Q And isn't it also a fact that he claims that the Oelsen data is too high -- this is calorie data -- is too high by 800 calories?

A No, he claims that -- or he agrees with the Oelsen statement of his own accuracy of about 10 percent.

Q Mr. Sprung, isn't it a fact that the exothermic reaction, which discussed -- which is discussed in the patent in suit, 515, is that a reaction which occurs while the particle is in the flame and in flight?

A Generally.

Q It is that contribution of heat from the

exothermic reaction which aids in bonding, isn't that true?

A That plus some other phenomenon that's going on, but that is -- contributes.

Q Well, I am only saying it's the heat now, the exothermic reaction which generates the additional increment of heat, which aids in bonding? You don't deny that the addition heat aids in bonding, do you?

A No.

Q No, it does aid in bonding. And it's that heat which is converted to this particle, the additional increment of heat so that the heat we're concerned about is the heat which occurs in flight, isn't that true?

A Generally.

Q Which means it is after this particle has seen th heat of that flame and is now molten or at least you have the intermettalic reaction causing the exothermic reaction, isn't that true?

A Or possibly continuing to some extent on the surface.

Q Is the patent concerned with the exothermic reaction which occurs in flight? Do you know?

A I don't think the patent spells that out.

Q All right, look at column 12, line 20.

Do you see it, sir? Column 12, line 20, it starts "nickel aluminide composite."

A Yes, that is -- that is with respect to an example.

Q Well, are you familiar with any example which suggests otherwise? The nickel and aluminum composite powdered mixture reacts exothermically in the flame to provide self-bonding properties and so forth and so on.

A I am only saying that that doesn't rule out auxiliary effects. Yes, it does react exothermically in the flame but it doesn't rul out the fact that there could be some continuing exothermic reaction when it hits the substrate.

Q I understand what you're saying. I'm asking whether the patent discloses it?

A The patent doesn't go into depth on the matter.

Q Discloses a reaction other than, or the timing of the reaction other than what appears in column 20?

A I don't recall further detail.

* * *

Q Do we have anything offered by Metco other than Post which shows the nature of the -- the nature of the coating, period?

A I have not produced --

Q All right. Will you look at Exhibit 43 again. This is the article by Longo. This is the one which has the acknowledgment referring to you. Will you turn to page three, the part entitled "Metallurgical Results," beginning

with Metco 404.

Now, did you participate in the preparation of that section?

A I was Mr. Longo's supervisor at the time he was doing the work as is reported on page 3.

Q Do you recall reading this section of the report which appears on page 3?

A Yes.

Q Now, if you look at the first paragraph, the second sentence, it refers to the individual particles composed of several metal-like phases.

A Yes.

Q Now, the next paragraph, third line from the bottom, refers to nickel-rich, nickel aluminide and so forth. Is that nickel aluminum he is referring to? I see he does say stoichiometric NI_3AL.

A Yes. He refers to NIAL. At that point he is referring to stoichiometric NIAL.

Q Doesn't he also mention that while the NS phase was identified as NI_3AL --

A Yes, he goes on to say that.

Q He refers to both, doesn't he?

A Yes.

Q Now, if you look at this phase diagram, where

do you get NIAL and NI_3AL occurring? NIAL and NI_3AL are both nickel aluminide, right?

A Yes.

Q Now, tell us where in this diagram do you get NI_3AL and NIAL occurring?

A On the equilibrium diagram.

Q That's what he is referring to, is he not?

A No.

Q All right. Then on the equilibrium diagram, where do you obtain the NIAL and NI_3AL?

A The NIAL phase is the one labelled Beta Prime, which your finger is almost on.

Q He is referring or marking this with regard to room temperature? This is the coating.

A The coating is at room temperature.

Q So that if you come down to the 80% line at about room temperature, we would be in this region, and this region has both the NIAL and the NI_3AL; is that correct?

A That region on the phase diagram. But his is not directly -- this is not an equilibrium coating.

Q But it does -- on the phase diagram, the NI_3AL and NIAL do occur where you have 80% nickel and 20% aluminum?

A On a slow cooled -- very slow cooled system as reported by the phase diagram. There would be two phases,

NIAL type phase and NI_3AL type phase.

Q All right. Now look at the last paragraph on page 3.

Composition of each metal 404 particle.

A Yes.

Q Is 80% nickel and 20% aluminum?

A Yes.

Q Under equilibrium conditions, this would place the alloy in the two-phase region of NIAL plus NI_3AL?

A Yes.

Q Is he referring to equilibrium conditions as exhibited in this nickel phase diagram?

A That's what he is referring to. It would place it there if it was equilibrium.

Q Pardon me?

A The sentence says, under equilibrium conditions this would place the alloy --

Q Yes. And in paragraph two that's what he found; isn't that true?

A That doesn't prove it's equilibrium.

4/2

Q No, I didn't say that, sir. I said in the last paragraph he refers to the equilibrium diagram as the reference for -- let me try it again.

In the last paragraph he refers to the alloy

occurring in the two-phase diagram or two-phase region of NIAL and NI_3AL by reference to the nickel phase diagram, Exhibit 66A, and in the second paragraph he says that's what he found, NIAL and NI_3AL; isn't that correct?

A He said he found those phases, yes.

Q Yes. Now, look at page four where reference is made to Metco 450. Do you recall reading this when it was prepared by Mr. Longo?

A No. Not until after this was published. This was printed in-- or published or written in two eras. The section on 404 was written in the early 1960s, at which time I was his supervisor. At the time he prepared the section on 405 and 450 he was not in my department, and I was unaware of this until it was printed.

Q When was it printed?

A It says copyrighted 1970. That's when it was printed.

Q Have you -- is there any writing by you to Mr. Longo or anyone else indicating any disagreement by you with regard to the text of this paragraph entitled Metco 450 appearing on page four?

A I don't recall any written communication.

Q Now, he refers to a comparison that was made between the particle structure of Metco 404 with the Metco 450. Do you know how that comparison was made?

Perhaps it would be useful, Mr. Ingham, to start at the beginning of that. The Metco 450 is a composite powder comprising 4.5% aluminum applied to the nickel core. Do you agree with that?

A Normally, yes.

Q The next sentence. The exothermic combination results in coating of very high density. Do you agree with that?

A Yes.

Q How does that coating of high density compare with the Metco 404 coating? Is it as high, higher than or less?

A I don't see any direct comparison.

Q Do you know of it, sir?

A I don't recall.

Q Okay. The next paragraph. Particle structure was compared to standards as were Metco's 404 coating.

A The next paragraph?

Q Next line beginning with the word "Particle."

A Yes.

Q The particle structure was compared to standards as were Metco 404 coatings and found to be primarily nickel with some nickel/aluminum solid solution.

Now, do you know what standards were used?

A He's referring to different phases which -- and the standards are discussed in the earlier part of this article.

(Continued on next page.)

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CROSS-EXAMINATION

BY MR. CALIMAFDE (Cont'd):

Q Now, next line he wrote, "Only minor percentages of non-stoichiometric, NiAl, and Ni^3Al, estimated at less than five per cent were found."

Do you know what test was used to determine that less than five per cent of NiAl, and Ni^3Al existed?

A Metallurgy, which I said is relatively crude --

Q Do you have those tests with you?

A His tests?

MR. CALIMAFDE: Strike that.

Q Do you know whether those tests are available?

A I don't know.

Q Down to the second from the last sentence beginning with the word "Micro-hardness." First the word "Micro-hardness" suggest it is a hardness factor?

A Yes. It is a way of picking out phases.

Q Micro-hardness verifies the absence of NiAl since particle hardness have thermo-spray coatings, and he gives the value DPH 150?

A He is referring to the absence of the NiAl phase.

Q As compared to 404, does the 404 have a substantially higher micro-hardness than the 450?

A Yes, it has phases in it that are harder.

Q And the phases are NiAl and Ni^3Al?

A Yes.

Q The last sentence reads because of the small quantity of the Al in 450 powder, there is seldom any free aluminum found in a properly sprayed coating.

Do you agree with that statement?

A Yes. Free would mean bits and pieces of aluminum that didn't react.

MR. SPRUNG: They keep referring to documents. They could have requested any documents they wanted --

MR. CAILLAFDE: Do you have an objection? Are you suggesting how I should conduct my discovery at this time?

THE COURT: I think, Mr. Sprung, we will continue.

Q In this same paragraph, let us address ourselves to the second and third sentences where again the second begins with the word "particle."

There he refers to the coating as being primarily nickel and then he uses with some-- he doesn't say nickel aluminide. He uses the expression "solid solution."

A He had been referring to a phase known as --

Q Just a minute.

Here he says primarily nickel with some nickel/aluminum solid solution.

The next sentence he doesn't use the expression "solid solution." He refers to a minor percentage of NiAl and Ni_3Al which earlier he identified as nickel aluminide.

Do you see that?

A Yes.

Q Do you agree with the use of the language as it is used in this paragraph?

A He is referring to the --

Q Do you agree with the use of the language?

A He is referring to the different phases and I agree with that language in referring to different phases.

Q Now, the last paragraph "x-ray defraction studied," and the last sentence in that paragraph on page 4, "Thus considering."

Do you see that?

A Yes.

Q Do you agree with it?

A The last paragraph it says "Thus considering the rather drastic quench rate normal for flame sprayed

coatings -- it appears that X-ray analysis couldn't distinguish between Ni, Ni_3Al or the solid solution of aluminum in nickel.

Q My question is, do you agree with that as a technical matter?

A With the rapid quench rate not distinguishing --

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(Continued on next page.)

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CROSS-EXAMINATION

BY MR. CALIMAFDE: (Cont.)

Q Do you agree with the technical accuracy of that statement thus considering the rather drastic quench rate, etc., it appears that X-ray analysis couldn't distinguish between nickel, nickel aluminide, Ni3Al or the solid solution of aluminum in nickel?

A I agree it says it can't distinguish these phases.

Q We all can read the language. I am asking whether you agree with the technical accuracy of the statement?

A I don't know how to answer otherwise.

Q If I understood you correctly, you agree that he made the statement and I say we can all read the language.

A No, I said I agree with his saying in the statement that the X-ray analysis couldn't distinguish between these different phases.

* * *

Q Have you made any tests at Metco, X-ray analysis tests at Metco of the 450 powder?

A No.

Q Let me talk about this sequence of things.

MR. CALIMAFDE: This may be a good time to break.

THE COURT: All right.

When you said with respect to the powder, do you mean with respect to the coatings produced by the powder as in the case 404?

MR. CALIMAFDE: Yes, sir, thank you.

THE COURT: Did you understand the question in terms,only in terms of the powder or in terms of the coating?

THE WITNESS: I understand it as the powder

but the answer would be the same.

THE COURT: No X-ray defraction analysis for the 450 coatings?

THE WITNESS: Right.

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AFTERNOON SESSION
(2:10 p.m.)

HERBERT S. INGHAM, JR.,

* * *

Q Did you have a chance to review Plaintiff's Exhibit 88 during the luncheon recess?

A Yes.

Q Do you agree or disagree with the curves shown on the exhibit which purport to be drawn from the data which you supplied us yesterday?

A I disagree.

Q Will you draw on that exhibit what you believe to be the correct curves, and then would you please identify by reference that part of the strip chart which supports your redrawing?

What color -- maybe you ought to use a color different from what we have up there.

THE COURT: Would one of these be practical or not? They are a little broad, I realize, but --

THE WITNESS: Is it blue?

THE COURT: It's broad.

MR. CALIHAFDE: Something other than red, green --

THE COURT: How about black? Wouldn't that do?

MR. CALIHAFDE: We have a black there.

THE COURT: But it would be a broad black.

MR. CALIHAFDE: All right. Then perhaps --

THE COURT: If it's not difficult to sketch with.

BY MR. CALIHAFDE:

Q Tell us first what you are drawing for the record?

A I am correcting the curve for the 404 here and I calculated from the location where it is going rapidly upward, I find that it goes much further upwards to about that type of height.

Q And perhaps --

A The continuation I did not recalculate so I have only carried the calculation this far.

Q Perhaps you should put a reference numeral next to the dashed lines you have drawn. Call it letter "A" and the dash marks; correct?

A And that was derived from the strip charts here.

Q Yes. Are there any other corrections to the curves?

A No, that's the correction.

Q It is unnecessary from my viewpoint to do that change in the strip chart, your Honor, unless someone would prefer to do it.

MR. CALIMAFDE: We now offer Exhibit 88.

THE CLERK: One chart marked for identification as Plaintiff's Exhibit 88 is received.

(So marked.)

THE COURT: What really is the correction, then, in sum?

THE WITNESS: Well, the correction is that the 404 airplot was much lower than it should have been and I have raised it up to a height where I calculated it to be --

MR. CALIMAFDE: For the record, your Honor, 404 in air, as drawn by plaintiff, showed a peak of about 144 degrees.

THE COURT: I see.

MR. CALIMAFDE: As redrawn by the witness, the 404 powder in air shows a peak rise of about

217 degrees.

THE WITNESS: My actual calculations point, which was only scattered point -- it actually doesn't represent necessarily the peak -- but it was 211.

BY MR. CALIMAFDE:

Q 211?

A At the two-minute point.

THE COURT: Well, in other words, 217 is not correct?

THE WITNESS: His -- my -- my point that I -- I didn't point every -- I wasn't able in time to plot every little point. I have a point at 211 --

Q Is that the peak?

A (Continuing) -- of 211 at two minutes.

Q Is that the peak temperature, 211?

A No, I don't know. It could have gone slightly higher but I don't think it is enough to talk about.

Q All right, I will write in "Peak Temperature for A" at 211 degrees.

THE COURT: And that, of course, is centigrade?

MR. CALIMAFDE: And that is centigrade, yes.

Q So that as revised by you, the 404 in hydrogen remains the same at something like 284 degrees, the 404 in argon remains the same at something about 218 degress, and the 404 in air as revised by you is about 211 degrees --

A Yes.

Q (Continuing) -- all centigrade?

A I wasn't getting exactly the same numbers, but within the discussion I -- I think it's essentially satisfactory.

* * *

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Q Exhibit 22. It's in plaintiff's book of exhibits. Do you have it, sir?

A I have it.

Q Is this document in your handwriting?

A Yes.

Q Are you the person who struck the line through "AlPd" which appears on the right hand side, the right hand columr?

A That I cannot tell.

Q Did you write the word "prior" within parentheses?

A That appears to be my handwriting.

Q "AlPd" is aluminum palladium, is it not?

A Yes.

Q And aluminum and palladium are two metals, are they?

A Yes.

Q And would they exothermically react with each other?

A I now don't recall.

Q Now look at the last item on that page, "NiTi." That's nickel titanium, is it not?

A Yes.

Q And the word "prior" appears next to that. Did you write that word "prior?"

A Yes.

Q Now look in the left hand column. There is

"NiP." That's nickel phosphorous?

A Yes.

Q With two lines passing through it, striking out the "NiP." Did you strike out "NiP?"

A I don't know.

Q All right, now look at exhibit 24. Is this exhibit in your handwriting?

A Yes.

Q Will you come down to item 5. There is first the number 11 in parentheses. Do you see that?

A Yes.

Q And then it adds "NiP?"

A Yes.

Q Under that there is "NiTi" with an asterisk. Do you see that?

A Yes.

Q Then in paren it says "wire prior art." Do you see that?

A Yes.

Q Did you write in the words "wire prior art?"

A Yes.

Q Are nickel and titanium metals?

A Yes.

Q Would they exothermically react with each other?

A Yes.

Q Now, right under that you see "CuAl." That's copper aluminum, is it not?

A Yes.

Q And in parentheses you have ditto marks, meaning "wire prior art." Did you write that in?

A I wouldn't --

Q Did you put in the ditto marks under it?

A I wouldn't really know if those are my ditto marks.

Q Did I ask you whether copper and aluminum are metals?

A No.

Q Are they?

A Yes.

Q Do they exothermically react?

A Yes.

Q Did you review Table 1, which appears in the 515 patent and the 248 patent, before the application, the last application, was filed in 1964?

A Presumably.

Q Do you find in Table 1 any of the metal combinations indicated as prior or prior art in the exhibits 22 to 24, namely nickel titanium, copper aluminum or aluminum palladium?

MR. SPRUNG: We could speed it. Are they in there?

MR. CALIMAFDE: Pardon?

MR. SPRUNG: Are they in there? Does he have to check them?

MR. CALIMAFDE: No, I don't find them there. If you will accept my representation I'll move on.

THE WITNESS: I'll accept that.

* * *

Q Now, what did you mean, Mr. Ingham, when you said prior -- when you wrote "prior" next to aluminum palladium in exhibit 22?

A This would have been an indication that I was aware of some wire prior to the date whenever these notes were made, around '64, and there was in the early '60s some stuff known as fuse wire.

THE COURT: Fuse?

THE WITNESS: Fuse. And carrying that a step further, we were concerned about spraying wire that would act like a fuse, in that once this would be sprayed with the wire gun and once the tip of the wire was heated we were fearful

that the wire tip would act like a fuse and go back inside the gun, and we wouldn't be able to spray with it.

There were considerations of further intention to get around this, which would have been further invention beyond the scope of this present patent, and I believe -- I -- I can't remember just what was going on in our minds then, but I believe we were fearful that an explicit -- explicit example of a fuse combination might rule us out on a further improvement type of patent.

(Continued on next page.)

Q The Exhibit 22 --

A I note also in this entire context that titanium nickel as a powder is in the patent as Example 6.

Q Yes, I was about to mention that, whether you knew or could explain why nickel titanium appears as Example 6 and yet is omitted from the table.

A Well, that would be in that context that powder we weren't concerned about acting like a fuse and requiring further invention to improve over it.

Q Well, nickel titanium is a pair of two metals wh' react exothermically.

A Yes, and this -- this --

Q Now, why isn't nickel titanium, if you know, in the table?

A For the reason I just explained.

Q Then why is it an example, Example 6?

A The example is explicitly as a powder. The table would imply wires as well as powders.

Q So that nickel titanium as a wire is prior art but nickel titanium as a powder is what you purport or attempt to cover in this patent?

MR. SPRUNG: He didn't testify it was prior art.

MR. CALIMAFDE: Well, I'm reading his language.

He says "wire prior art" in Exhibit 24.

MR. SPRUNG: He said prior art to his own invention, his own improvement.

MR. CALIMAFDE: I am only reading what is here.

MR. SPRUNG: Well, he just explained what he meant.

THE WITNESS: This invention, as I have understood it all along, has the priority date of 1960, and we are now talking about another completely possible different invention that would have been in the middle'60's, and then we would have been concerned about the prior art situation.

Q So that your reason for not informing -- strike that.

Your reason for not including nickel titanium -- let us take an example -- in the table is that as a wire it was prior art? That's in the '64 application, the 1964 application?

A I was aware of some -- some wire available as fuse wire in the early 60's.

Q That same answer applies to copper aluminum, where on Exhibit 24 you have ditto marks for "wire prior art"?

A I don't recall how that would apply to copper aluminum. I'm -- there is an indication that it's less than 7500 calories. I don't recall the context of that.

Q Do you recall the context for writing the word "prior" in Exhibit 2, next to aluminum palladium?

A It's possible. It was a long time ago. It's possible that was one of the fuse wire items.

Q Are you now speculating, Mister --

A I am not speculating on notes and what might have happened ten years ago.

Q All right, in the preamble to the table, right after Example 33, it says "Table 1 below gives examples of further component pairs which may be used to form the powders and/or wires." Do you see that?

A Yes.

Q Now, despite that preamble was it your testimony that you omitted nickel titanium from the table because you believed it existed as a wire in prior art but not as a powder?

A I was -- that is my recollection was that I was worried about a subsequent patent we might file. Not with respect to this patent.

Q All right.

A And -- and that statement that you just read doesn't

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indicate that this table has to be all-inclusive. It's just examples of further pairs.

Q You have referred to the Bradstreet patent?

A Yes.

Q This patent discloses a powder for flame spray. Have you read this patent previously?

I think you testified on direct that you had?

A Yes.

Q It does refer or disclose a powder for flame spray and the powder includes aluminum?

A Yes.

Q The aluminum is in the amount of five to seven percent by weight of composition?

A Yes.

Q The aluminum undergoes an exothermic reaction?

A Yes.

Q While in the flame?

A Yes.

Q To raise the temperature of composition?

A Yes.

Q The particles as disclosed by Bradstreet, they reach the surface to be coated at their highest temperature?

A I don't recall that statement.

Q Look at column six, line sixteen.

A Yes, it says particles should reach the surface to be coated at their highest temperature.

Q Isn't it a fact that Bradstreet recognized in its patent disclosure that even a small amount of a flame can make the difference between securing an adherent coating on to the surface, or a coating that is likely to crumble off?

A Yes, certainly adherent as compared to crumbling.

Q Does he recognize that the flame catalyst adds to the temperature of the composition?

A Yes.

Q And the Bradstreet patent which discloses an amount of five percent by weight of aluminum, if nickel were substituted for the metal oxide would there be any substantial difference between Bradstreet and the Exotec powder?

A Bradstreet powder is a blend, so, yes, there would be a difference.

Q In that composite then, Bradstreet would be a mixture?

A That is a physical difference.

Q We have a difference.

A He certainly teaches that the exothermic reaction is one of burning in the air in the process of flame spray which his patent is directed at.

Q And that the aluminum is the source of the exothermic reaction that generates the additional heat?

A Yes.

Q I refer to the Haglund patent.

I assume you read that?

A Yes.

Q Haglund discloses a material for flame spraying in composite form.

A Some of it is composite.

Q So he discloses a material for flame spraying in composite form ?

A Yes.

Q The material includes aluminum?

A Yes.

Q Plus refractory?

A Yes.

Q He indicates that aluminum has a strong positive heat reaction?

A Yes.

Q Does he also disclose that the aluminum reacts exothermically?

A Yes.

Q To raise the temperature of the material?

A I don't specifically see where he speaks of raising the temperature of the material.

Could you point it out?

A In column one, beginning at fifty five, the words are not the same, but the sentence begins with the reaction between

aluminum and dioxide is exothermic in nature, which means that heat will be given off, yes.

Q If heat is given off in this exothermic reaction, isn't it the effect to raise the temperature of the material?

A That would be speculation.

Q Can you make that speculation?

A No.

Q I will come back to that.

Doesn't he disclose a piece there, aluminum has a critical influence on the result obtained by the flame spray technique.

Look at column three, lines one, two and three?

A It says the grain size of the aluminum powder has a critical influence.

Q If you start at that paragraph at the bottom of column two, it has been found that the amount of grain besides the aluminum has a critical influence on the result obtained, he mentions a range of two to six percent.

Is that right?

A Yes.

Q Isn't it a fact that Haglund also recognizes the importance of the incremental increase in heat and as a result uses the aluminum for producing that incremental increase in heat?

A This patent, and so does the Bradstreet patent, makes the statement --

Q Answer my question.

A These are not bonding materials.

That heat, if it is there, does not achieve that result.

Q You mean based on your testing of the powder which presumably resembles the powders disclosed in those two patents --

A Based on that as well as the entire history of experience flame spraying many materials similar and different which become recognized as suitable for different purposes.

Q In the Haglund patent, if nickel were substituted for the refractory, would there be any substantial difference between Haglund and the Exotec powder.

A Can we take the individual examples?

Q Can you answer my question as worded?

A Yes, there would be a substantial difference.

Q What would that be?

A Example one is a wire comprising of mixture.

Q Can't you answer that question without resorting to examples.

A That is made of a powder. It is cindering in a furnace at 1200 degrees and then it is crushed.

That certainly wouldn't make a powder anything like the fused powders.

Q You are limiting yourself to the description in the example?

A I can take any part of it.

If you wish --

Q Just a moment.

If you wish to limit yourself to any example, you can do it. I will move on.

A I read elsewhere that the refractory is mixed with powdered particles of a metal for instance aluminum. That is a mixture.

Q Are you referring to an example?

A No.

That is a column one, line 38, where it says accordingly the pre-invention, the individual particles of such coated materials were an oxide film of silicone oxide or mixed with a powder mixture for instance aluminum.

Q You are simply saying if we substituted nickel for the refractory in Haglund, it would be your opinion that Haglund wouldn't produce a powder similar to it?

A That is correct.

Q Let us go to the Shwayder patent.

Does this disclose a flame spray powder in composite form?

A This is a composite of nickel and tungsten carbon.

Q According to the patent, is the nickel melted by

the heat, has the particles -- well, is the nickel melted by the heat as the particles travel toward the work piece?

A I don't see anything about melting.

Q Column three.

Do you see it?

A Yes, I am sorry.

Q As the particles travel toward the work piece and it cements the particles to the work piece, the melted nickel cements the particles to the work piece.

A That is the phrase he uses.

Q And the nickel is fused to the metal surface?

A I don't see the word fused.

Q Claim one, line 32.

A All right.

Q If in this patent, a small percentage of nickel were added to raise the temperature of the material as suggested by Bradstreet or Haglund, --

THE COURT: Don't you mean aluminum?

MR. CALIMAFDE: Yes.

Q If in this patent, a smaller percentage of aluminum were added to raise the temperature of the material as suggested by Bradstreet and Hanglund, then there would be no substantial difference between Shwayder and the 515 patent.

A The context of Schwayder patent is the heating of the work piece as well as the particles to a temperature that will fuse, so that it is of the spraying weld or self-fluxing or self-fusing type of process, and that is the context of this fuse.

Q On column two, we have the section entitled hard surfacing by flame spraying?

A Yes.

Q Let us direct ourselves to that.

In column three, he explains from where the heat comes, that is applied to the work surface.

It begins at line 11 in column three, with this hard bracing material at a low metal point, and a wide --

A That is a self-fluxing alloyed material.

Q And thus increased adhesion of the particles to the work piece.

The amount of the colmonoid number six added if any is desired for any particular application, depends on the speed of the flame spraying, the heat, the work piece and may be determined by tests.

A What it simply says is colmonoid number six can be used to improve the situation.

* * *

Q It's quite obvious, is it not, when you have a gun which is at 5,000 degrees Farenheit, 5 to 7 inches from a work piece, you would be simultaneously heating the work piece as you're spraying the metal on it. In fact, you cannot avoid simultaneously heating the work piece, could yu?

A There would be a little bit, but when they go out of the way to teach it and use the word hard surfacing, then that is talking about something that is known in the art, those phrases mean something to somebody in flame spraying; that he heats the work piece up to a much higher temperature whereas as came out earlier, in my own testimony and even in documents from Eutectic, the work piece is not supposed to get higher than 500 degrees in ordinary flame spraying.

Here, he is teaching to heat the work piece to get a different result. One would read this patent forgetting the fused type of coating by applying the flame heat.

Q Look at column 3 now where he goes on talking about the process beginning with the first full sentence "However, by nickel coating the particles as herein described, the nickel coating being melted by the heat --" the flame sprayed heat -- "as the particles travel towards the work piece."

A Yes.

Q "Cements the particle to the work piece." It is

5

the heat --

A That is in the same paragraph.

Q Let me ask the question.

A Simultaneously flame heating the work piece.

Q Correct. Here, he's describing the nickel and the nickel is travelling towards the work piece, melted by the heat as the particles travel towards the work piece, cements the particles to the work piece and any loss of material is sustained by the coating rather than by the expensive tungsten carbide. The coating he's referring to there is the nickel coating; isn't he?

A (No response.)

Q This is a nickel coated tungsten particle; is it not?

A I have to check carefully because it also speaks of coating with a nickel phosphorous alloy. In this case, he says nickel, yes.

Q Yes. He starts with a tungsten carbide which is a hard material.

A Yes.

Q He coats it with nickel?

A Yes.

Q As a composite, isn't that true?

A Coating, yes.

Q Yes. That nickel coated carbide is flame sprayed onto a base metal?

A Yes.

Q The heat of the gun melts the nickel and to use his language "cements the particle to the work piece," and any loss of material is sustained by the coating rather than by the expensive tungsten carbide. He's using the nickel as a matrix to hold the tungsten carbide and to cement the tungsten carbide to the work piece?

A Yes.

Q Look at your example in the patent, column 12, beginning at line 19. You see that, nickel aluminum composite powder; do you have that?

A Yes.

Q "The nickel aluminum composite powder and the mixture reacts exothermically in the flame providing self-bonding properties of the mixture and being fully molten on impact to the substrate becomes the matrix which securely binds the tungsten particles together in the coating." So that the only thing missing from Schwayder is a small amount of aluminum.

He has a nickel coated tungsten carbide. The nickel serves the function at the matrix to cement the tungsten carbide to the work piece. If he had 20 percent by weight of

aluminum, then he would have 515 exactly, would he not?

A No.

Q Pardon me, sir?

A No.

Q Well, as I read example 21 --

A Example 21 discusses a nickel aluminum composite.

Q Yes?

A Is that what you said?

Q What I said was --

A Maybe I misunderstood you. You said simply adding some aluminum. Simply adding aluminum wouldn't do it.

Q In Schwayder, we should add aluminum so it's in composite form with the nickel?

A The nickel also with the tungsten?

Q Aren't you mixing the carbon tungsten --

A It's a very different form here. Example 21 discusses cobalt bonded tungsten carbide mixed with a composite of nickel aluminum.

(Continued on next page.)

3PM2nxt

=

SS:ss
3PM2

BY MR. CALIMAFDE:

Q Example 21 includes cobalt bonded tungsten carbide mixed with a nickel aluminum composite?

A Yes.

Q And Schwayder has a nickel cladded tungsten carbide?

A That is a form of cobalt tungsten carbide composite, but it is not what's known in the art as cobalt bonded tungsten carbide.

Q Do you recall in connection with your example 32 in the 515 patent which is an example in making the wire form?

A Yes.

Q In that wire form, you compact the nickel aluminum. You form a compact of the nickel aluminum powder and you contain it within an aluminum tube or tubing?

A Yes.

Q The Court asked whether the powder in exhibit 32 was a mere mixture. As I recall, your answer, you said it was held in tight physical relationship by the tubing?

A And the aluminum itself. The powdered aluminum forms around, fills in all the holes and forms an integral structure with the powdered nickel inside the tubing.

For example, when you break or cut off this wire, it stays together. The powder doesn't fall out the end, so it's

not a loose mixture. It is a structural, integral compact.

Q You don't have a binder in the powder between the nickel aluminum in example 32, do you?

A The aluminum itself acts as a binder, the aluminum powder inside. It's soft and it forms around and between.

Q Let's explore what it is not. It is not a 404 type of construction. It is not nickel clad over aluminum, is it, in example 32?

A It's not a powder.

Q No. It's not a form in which the aluminum is held by a binder to the nickel core, is it?

A There is no other binder.

Q So that if you have the aluminum particle and the nickel particle simply compacted together and contained within the aluminum tube in example 32 --

A Yes.

Q The patent recognizes, does it not, that the aluminum will melt in the wire form, the aluminum will melt first.

In other words, it is the first material to melt?

A In the case of wire, does it say that?

Q Yes.

A Where are you referring to?

Q I'm referring to the patent. I thought, perhaps you knew from your familiarity with the patent. If not, look at column 3.

Do you know, first, that the patent does say it? We can move along faster if you do know it.

A Do I have a question?

Q Yes, the question is doesn't the patent recognize that the aluminum in wire form is going to be the first element to melt away?

A It may. I just don't recall the circumstance here.

Q For example, if you look in column 3, beginning at line 30, there is described a wire of nickel and aluminum. The statement is made "The core must be nickel, otherwise --"

A Yes, all right.

Q "The aluminum will melt out first."

A Now I know what you're talking about.

Q If you make your tubing out of the aluminum, the aluminum melts first. Now, you have a mixture in mid air of nickel aluminum, do you not?

A No.

Q You don't? All right, look at the Herz patent for a moment.

A The Herz patent?

Q Yes, H-e-r-z. Herz discloses, of course, that

nickel and aluminum composite. You have Herz, Mr. Ingham?

A Yes.

Q He discloses a composite of nickel aluminum powder, does he not?

A I don't think so.

Q Does he disclose a compacted slug, to use his word, of about 2 inches in diameter and 2 inches high of nickel and aluminum particles?

A I've heard the phrase.

Q In column 2, beginning with line 64, where he discusses the making of the slug --

A Practice to compact the powder mixture of nickel aluminum and zirconium into solid slugs.

Q Then he gives dimensions about 2 inches high and 2 inches in diameter. Do you see that?

A Yes.

Q Now, if you take that slug and you place it in a tube of aluminum of suitable size for flame spraying, then you have the 405, example 32-A, do you not?

A No. Wire isn't 2 inches in diameter.

Q No, I said if you take that slug and, of course, elongate it and place it into an aluminum tubing of a size suitable for flame spraying, then you have example 32-A?

A You're adding a lot of steps that aren't described

here.

Q Let's talk about Maskiw for a moment, a very brief moment. You've heard about the number of combinations in Maskiw. Isn't it a fact Maskiw mentions a number of cladding metals and a number of core metals by, I think, I heard, if you take every possible combination, it comes out to be a number in the 400's.

MR. SPRUNG: 455.

Q If you look at the group of 4, which appear in line 37 of column 2, the group of silver, copper, nickel and cobalt and you calculate your possible combinations, you reduce it to about 140 or 144 -- 136. Do you wish to take my word for the arithmetic?

A All right.

Q The number of combinations in your patent, as I read it, is 142. Do you know how many of the Maskiw combinations coincide exactly with the number of combinations in table 1 of the patent 515?

A No, I haven't made that comparison.

Q My arithmetic tells me 12. It doesn't surprise you to hear there are 12 identical combinations in Maskiw and the patent --

A 12 out of the 455?

Q 12 out of 136, 136 in Maskiw; 142 in the 515

patent; that there are 12 identical combinations appearing in both tables.

Let's go on to the Gutzeit patent for a brief moment. As I understand it, Dr. Ingham, you tested the material which you obtained from the Kanigen people; is that correct?

A The Kanigen people?

Q I may not be using the correct name to describe the supplier of the powder. Is it called the Kanigen process or Kanigen powder? You used the expression on your direct examination.

A I called it a nickel precipitate, a waste material obtainable from users of the so-called Kanigen process.

Q You purchased this powder from a supplier?

A Yes, there's a document.

Q The powder you purchased contained how much phosphorous and how much nickel?

A I found it out to be about 9 percent phosphorous.

Q Pardon me, sir?

A 9 percent phosphorous.

Q 9 percent phosphorous, that would make it about 81 percent (sic) nickel?

A I believe so ---

Q 91 percent.

A I believe so.

Q Did that proportion correspond to any of the nickel phosphorous examples appearing in the earlier applications, do you know?

A Any of the earlier applications?

Q The patent applications that contained the nickel phosphorous example?

A You mean the earlier application preceding the 515 patent?

Q Yes sir.

* * *

Q All right. "Footnote 7 with 404 powders and 404 N.S. powders, proper spray distances especially important,

bond strength, reliability fall off rapidly outside of the recommended range." Is that same statement applied to a nickel phosphorous powder?

A I don't know. Since I got zero bond strength at different parameters, I don't know whereby any falling off since it would be falling off on zero. If you're comparing with something in example 11 in talking about excellent coating, example 11 is not the Gutzeit material.

Q What is example 11?

A Example 11 says "A nucleus of elemental phosphorous powder was coated with nickel to form a nickel clad flame spray powder." This is a nucleus of phosphorous and coated with a cladding of nickel. That's not the same as the Gutzeit.

Q I directed your attention to the wrong example. It's example 5. Is that the Gutzeit powder?

A That's not the Gutzeit powder. That says, example 5 says "A nickel phosphorous powder, having a size between and containing 8 to 12 percent phosphorous is coated with nickel." The Gutzeit powder isn't coated with nickel in the Gutzeit patent. Again, it's under different circumstances.

* * *

Q Let me conclude this examination by discussing this briefly with you, Dr. Ingham.

THE COURT: What exhibits again is that?

MR. CALIMAFDE: MK.

Q In your square numberes 1, you show a particle which you entitle aluminum clad nickel powder. Do you have any photograph which purports to show a particle within the aluminum is directly in contact with the nickel core?

A I think I testified on that whole matter.

Q Is the answer you do not have a photograph which shows?

A I did not bring in photographs.

Q Pardon?

A I did not bring in photographs.

Q You do not have any photographs in Court which show the aluminum in direct contact with the nickel core; is that correct?

A (No response.)

Q Is this powder particle supposedly representative of a Metco 450 powder?

A I think as I testified earlier, that this was schematically representative of the 450 and the accused powders

and was not intended to be any one particular powder. I even believe I testified that one can expect variations in the degree is cladding, but that doesn't change the consent.

Q Isn't it a fact that except for those two photographs produced by Patel, which he said represented less than 1 percent of all the particles he had observed which were more than 100, all of the photographs of the particles showed an incomplete enclosure of the nickel by aluminum?

A I think that various degrees of completeness are there.

Q Looking at your example KM -- N

A I also think the scan electron microscope pictures which you brought into the picture don't show any gaps in the aluminum cladding.

Finally, I haven't -- since you're pressing it, I haven't said too much about this. The mechanism or mechanics of mounting a particle like this where the aluminum is held onto the nickel nucleus with a binder, the mechanics of mounting these involves going through a process of sectioning and polishing with a grit, grinding material. My experience with this technique is that, through the years, we've gradually been able to improve it and get better and better results, but there is an obvious tendency for it to move around the aluminum particles and therefore, the exact appearance from such a section, I don't think is entirely representative.

Q Let me try to make my questions more concise and I would ask you to make your answers more concise if possible. Your exhibit KN is not of a 95/5 powder, but 85/15 powder, is that correct?

A That's correct.

Q In this exhibit, if we look at the one which shows the least amount of surrounding of aluminum, we would have a nickel core with aluminum expending or overlapping one portion, but each aluminum particle is sprayed by a binder, isn't that true?

A I think I testified to that effect there is a little bit of binder, but you can't tell from such pictures how wide a gap it is.

Q The fact is there is a binder around the aluminum particle?

A Yes.

Q Is there a binder separating the aluminum particles from the nickel core?

A That can separate the binder --

Q Is there a binder separating the aluminum nickel core?

A A thin layer.

Q Let me see if I can draw up here just very briefly what we're talking about. If that's a nickel core,

then we have a layer (indicating) of binder which you say is a very thin layer and then if we look at your examination, KN and we look at the center showing, you've got particles, clusters of particles. Each of these particles is surrounded with a binder as well as a binder existing between the aluminum and the nickel.

The second square is supposed to represent what happens after it's been subjected to a flame; is that correct?

A (No response.)

(Continued on next page.)

FL next

Do you know the melting temperature of the particle -- of the binder? The melting temperature of the binder?

A It starts to soften up, oh, 3- 400 degrees.

Q 3- to 400?

A Yes.

Q So does it burn off by the time you get to 600 degrees?

A Not in this short time period.

Q Pardon me, sir?

A Not in this short time period.

Q Well, in this short time period we're talking about we have this particle --

A Well, perhaps -- well, perhaps it is just being burned off as it reaches the 660 degrees.

Q In the short time period of one to two milli-seconds, is that right? That's what you're talking about?

A Well, it's even less than that, since we're talking about the initial stages.

Q This particle comes, is impinged by a flame of what, 5,000 degrees?

A Yes, and I even think that flame would help push those aluminum particles closer to the nucleus.

Q Let me ask the questions and we'll find out what happens, if we can: The flame is at 5,000 degrees Fahrenheit,

and the nickel particle comes into the path or is subjected to the intensity or heat of the flame; the binder begins to melt at 3- to 400 degrees; at what temperature does the aluminum begin to react exothermically?

A 660

Q That's the --

A That was -- it should be about 2- to 300.

Q 2- to 300 centigrade?

A These are round numbers.

Q And this is the melting temperature, or is this the ignition temperature for the exothermic reaction?

A Well, the -- first the melting temperature of the aluminum, and the ignition temperature would occur when the aluminum has melted.

Q That's one of these pieces of information which you said you read in the Bureau of Mines article, that the ignition temperature is higher than the melting temperature?

A If you're talking about -- by ignition I'm referring to in this case the reaction between the nickel and aluminum.

Q Talking about the reaction between the aluminum and the oxygen?

Oh, that would be at a higher temperature.

Higher than what, melting?

Higher than 660.

Q Yes. Now, I asked you I believe where you got that information from. Is that what you said, you got it from the Bureau of Mines?

A That was in some Bureau of Mines typeof thing.

MR. SPRUNG: Do you want -- we've brought in the book, if you want it.

Q Let me show you a book, or an abstract, a few pages, rather, from the book entitled, "Powder Metallurgy and Nuclear Engineering," which gives the ignition temperature for aluminum at 645 degrees C.

A I'm not familiar with this reference and it says something about O2. Is that ozone? Does it apply to this case?

Q "Ignition and explosion properties of dust clouds. Aluminum through 270 mesh. Ignition temperature 645 degrees C."

A The next column says something about O2, ozone?

Q "Concentration of ozone per cubic foot."

A I don't -- that must not apply to this kind of situation. There is no ozone here.

Q Well, in your book of the Bureau of Mines does it show an ignition temperature?

A Yes, sir.

MR. SPRUNG: Yes. Can we mark that as an exhibit?

MR. CALIMAFDE: We certainly can. Let's offer

it, because as we read this it shows that the ignition temperature is below the melting temperature of aluminum.

THE WITNESS: And aluminum which has melted around the nickel --

Q That's not my question, sir, not what has melted. I'm asking whether the aluminum, the fine powder aluminum, will ignite exothermically with the oxygen prior to the time it melts.

A This gives different data for different sizes, and --

Q Take the finest size of the particle.

A And the finest size, and I think the powder which -- it's hard to judge exactly from what is in here, but approximately the finest size represented here is probably still not as fine as the powder which is clad onto the 450.

Q So the finer it is --

A The finer it is the lower --

Q (Continuirg) -- the lower will be the ignition temperature?

A Now we have almost complete evidence thoughout this entire trial that nothing has taken place until the particle has reached the melting of the aluminum.

Q No, we haven't established that at all, Mr. Ingham.

A And once it has, then it acts like a large particle,

and the temperature is 900 degrees.

Q Mr. Ingham, let's stop playing games with each other. The question is very specific: I asked you at what temperature does the aluminum --

MR. SPRUNG: Well, I object to that characterization. Dr. Grant clearly testified that nothing occurred until the melting point in his graphs.

Q I'm asking you whether there is in this paper from the Bureau of Mines a temperature at which the aluminum will react exothermically with oxygen.

A This refers to free aluminum dust that does not have any binder and nickel involved.

Q Well, what is the ignition temperature for the free aluminum dust in the Bureau of Mines article?

A Where there is -- where there is no binder resin and nickel involved this particular temperature is 490 degrees.

Q 490 degrees C, ignition temperature --

A Of the dust, if it's disconnected and free of surrounding resin and nickel.

Q Of aluminum dust. Yes. Now, what is the melting temperature, if it is given in that same article, of aluminum?

A This article I don't believe goes into melting temperatures.

Q Is the melting temperature 660 degrees, as you have previously given it?

A Yes.

Q All right, so that now in effect we have dust particles contained within a binder, dust particles of aluminum contained within a binder about the nickel core, is that correct?

A Clad on to the nickel core.

Q All right, now, that's subjected to a temperature of 5,000 degrees Fahrenheit flame?

A Well, when you say subjected --

Q Yes, when this is subjected to a flame at 5,000 Fahrenheit isn't it true that the first thing to go would be the binder, since it had a melting temperature of 2- to 300 degrees, Fahrenheit?

A It will start to go, but we have such a short time that it can't go that fast.

Q Well, on what do you base that information of that statement?

A Well, considerable --

Q Do you have any facts to --

A Considerable evidence. For example, very specifically this 430 powder, as you asked earlier as to why it was developed, it is a very low smoke material. The amount of

smoke generated --

Q Can you answer my question, sir?

A (Continuing) --from burning aluminum is almost nil in this powder, so there is no evidence of burning aluminum dust.

Whereas when we blend this kind of powder with the nickel and spray it there is considerable evidence of the smoke, and I think that is direct evidence that the aluminum has not ignited in that fine form and that it has been protected by the resin.

Q Have you ever taken a particle, subjected it to a flame or a temperature of 2- to 300 degrees Centigrade, and then examined that particle?

A No.

Q Have you ever taken a particle and subjected it to a temperature of just under 490 degrees, and then examined it, just prior to the ignition point of aluminum?

A Have I examined it while it's at a temperature of 490 degrees?

Q No, have you ever heated a particle to a temperature higher than the binder's melting temperature but less than the ignition temperature of aluminum?

A No, that would have no correlation with flame conditions.

Q Now, if the binder melts, assuming that this

remains in flight during the period of time when the binder melts away, isn't it a fact you have a dust of aluminum simply surrounding the nickel core but traveling in space at a very high velocity?

A I don't believe the binder has melted away by that point.

Q But you have no knowledge of that, is that correct?

A Based on very strong visual evidence of the spraying.

Q You would visualize the binder as it's being sprayed at one or two milliseconds?

A I visualize this smoke that either comes off or doesn't.

Q But the smoke that you referred to is in connection with the 404 particle which has nickel on the outside and 20 percent aluminum on the inside, is that correct?

A No, no, I'm referring to the smoke that is generated with a simple blend of nickel and the fine aluminum, the blend of 5 percent aluminum without any binder.

Q In examining the coating have you ever detected any amounts of this binder resin in the coating?

A No, I think that is many steps along the way. I think by the time you've gotten to the coating the binder has essentially gone.

Q So you think the binder is going but it is more

slowly than the aluminum, which melts at a higher temperature?

A Well, for example there are six squares of progressions there, and the binder would only have to disappear in the time period of the first one, not the next five.

Q I want you to stay with this example for a moment before we go back to these squares. If the binder is not observed and has not been observed by you in your coating, in th spray coating which has undergone analysis, then the binder has left this structure sometime between the impingement of the flame and the time it arrived at the substrate?

A That would be correct.

* * *

Q Now, if the binder melts at 2- to 300 and the ignition temperature of the aluminum is less than the melting temperature, the aluminum will ignite before the metal, assuming these temperatures are correct; is that true?

A And also assuming that the binder has left by that point.

Q And assuming at least some of the binder has left at that point?

A Essentially --

Q Since it's going to melt away at 2- to 300?

A Essentially, all of.

Q Pardon me?

A Essentially, all of.

* * *

Q All right, if the binder had not disappeared but remained in homogenous state or in contact, then we had that binder between the aluminum and the nickel, so that we don't have contact between the aluminum and the nickel as long as the binder exists; isn't that true?

A There could just be a little spot of aluminum -- of -- of binder underneath the aluminum, and the aluminum can flow out beyond the binder.

Q There would be a little spot of an opening between the binder and the nickel, but there is no opening in the binder which surrounds the aluminum; that's your testimony?

A Yes.

Q If there is no little spot, open spot, between the nickel and the aluminum, so you do have a binder, then according to your sequence of events here the aluminum will never react with the nickel, will it, because the binder is separating the two?

A What?

Q I said assuming your --

A Oh.

Q (Continuing) -- hypothetical here --

A Well, I even visualize that the binder can still be there to a larger extent, and as the aluminum melts and -- and loses its shape it is in turbulence here and being pushed around onto the particle, it can flow over even a little bit of binder, but by then the binder is really going to melt and -- and move out of there.

Q The time is enough, that very brief time which is not enough to melt the binder is long enough to allow the aluminum to melt and flow homogenously, like a melted ice-cream cone?

A It works, so apparently that's the case.

Q Well, we'll find out if it works in terms of what's next, coatings.

But in terms of what is happening in flight, either the binder is there, and if it's there then your aluminum is not going to contact the nickel, isn't that correct, if the binder does not melt and the binder remains around the aluminum, so that the aluminum does not ignite, and the binder separates the aluminum from the nickel, then your aluminum is not going to react with the nickel if the binder is there?

A The binder has to be at least melted at this point.

Q If the binder has melted and left the aluminum,

now the aluminum temperature is such that it will ignite?

A Not if it's still connected through the binder to the nickel.

Q O.K. I feel I'm getting involved in argument. I don't want to do that.

You want it both ways, you want --

A The size of the particle has very much to do with whether it will ignite, because it has to do with the flow of heat.

Q Yes, you want it both ways, Mr. Ingham. You want the binder to remain there around the aluminum to prevent the aluminum from igniting, but you want the binder to move away from between the aluminum and the nickel so that the aluminum can melt?

MR. SPRUNG: I object. We are getting argumentative now. The witness --

MR. CALIMAFDE: I don't want to get argumentative, either.

Q Let's talk about this coating, because that's another hard fact. Do you have any evidence in regard to the coating which would support your theory that the aluminum melts on the nickel and reacts with the nickel?

A I don't think the coating, what -- what is in the coating is capable of demonstrating whether that has occurred.

Q Do you -- so that your answer is no, you don't have any -- you don't have any evidence which would support the theory?

A Not only don't I have evidence --

Q The theory that the aluminum would melt --

A (Continuing) -- but I don't think the coating can provide that evidence. At least -- let me put it another way: It may or may not provide that evidence.

Q If the aluminum melts on the nickel, as you suggest --

A No, I also -- I --

Q Let me ask the question: If the aluminum melts on the nickel, then according to this grand sequence of things you will have an aluminide reaction?

A Yes.

Q And if you have a nickel aluminide reaction that will be detectable in the final coating?

A Well, if --

Q Yes or no, sir?

A If it is detected then that has proven that it has reacted.

Q And --

A If it is not detected, that is not proof.

* * *

Q Now, you were asked in connection with the patents in suit whether there was any example showing 5 percent aluminum. What was your understanding of the word

example?

A The patent in suit, you mean the 515?

Q Let's look at the 515.

A Examples as are numbered, example 1, example 2, and so on.

Q Did you find other than numbered examples -- Is there anything, any exemplification of powder containing about 5 percent aluminum?

A Well, in addition to what is determined from the 3000 calories, as on column 3, right in the front on figure 1 "nickel clad aluminum," the geometry of that particle would correspond to about 5 weight percent aluminum.

Q Now in reference to the heats generated by reacting nickel and aluminum, and specifically we can refer to for example exhibit IW or IU, I believe -- well, it doesn't matter, let's look at IW.

A Or IV.

Q All right, we'll look at IV. Now, in the chart in the upper right hand corner of page 15, where they give the amount of calories per gram atom of nickel combining with aluminum, reference was made that this was done, and in the other exhibits, reference at room temperature. Would you explain to the Court what that means?

A Well, it means that they either actually or in

principle melt the individual constituents -- now, that means putting a certain amount of heat into a constituent aluminum and a certain amount of heat into a constituent nickel, and raising those two constituents up to some temperature above their melting points, and measuring the amount of heat that it took to just do that much.

Let's say that took an amount of heat A and suppose that's some number.

Then those two constituents are mixed together, and because of a reaction there will be much more heat generated, which will correspond to something we can call Delta H.

Then that whole thing is cooled back down again by taking heat out of it, back to room temperature. And that in practice the amount of heat you take back out of it will be approximately the same as the A. So that we have added a heat, we have obtained a Delta H heat on top of it, and then subtracted the A again. So the Delta H, which is the heat of the reaction that occurred up at the melting temperatures, is the -- approximately the heat that would be plotted on these kinds of graphs.

Q So the actual heat that is indicated is heat at melting temperatures?

A So that -- that could -- for -- there are small differences of the order of percents or 10 percent, which are

much, much less than what we are talking about at -- occurring at different temperatures. But the amount of heat shown, although it is referred to room temperature, that would also be the amount of heat one would expect when doing this up at the melting point.

* * *

Q Now, Dr. Ingham, during your cross-examination you were asked a number of questions concerning photographs, microphotographs, scanning electron, microscope photographs and electron bombardment photographs of composite or clad powders such as the Exotec powder. You were questioned why Metco did not supply this type of photographs of the accused powder during trial. Would you explain that to the Court?

A Well, apparently such questions were directed at whether we were trying to show that the accused powder -- powders had some physical shape or something, and it was my understanding right up to the time of the trial that they were not denying that these were composite powders made in accordance with the patent, and so I saw no need to. It was only during the trial they somehow stopped calling these composite powders. It particularly came out during Dr. Grant's testimony.

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Q According to your understanding of the 515 and 248 patents, what determines whether or not a particular powder is a composite or clad powder as set forth in the patents?

MR. CALIHAFDE: Doesn't the patent define it? The patent speaks for itself.

THE COURT: Well, how are you using those?

MR. SPRUNG: The patent defines clad as being a form of a composite.

I am trying to determine whether one -- what one does, how he determines whether a powder is a composite or clad as set forth in the patent.

MR. CALIMAFDE: The patent defines it.

MR. SPRUNG: If he answers the question it may solve it. The patent refers to --

THE COURT: I understand it distinguishes a composite from a mere mixture. We have been over that.

MR. SPRUNG: How does one looking at this patent determine whether a powder is a clad or composite powder?

THE COURT: I will permit the answer if you understand it.

THE WITNESS: I would say if powder is made according to the teaching of the patent then it is a clad or composite powder according to that patent.

BY MR. SPRUNG:

* * *

Q Dr. Ingham, while you are at the chart, PX 88, would you explain to the Court your understanding as to what that graph shows in terms of the reactions which may have taken place and the materials tested?

A Well, the additional thing which this chart has provided

over my original, which was Exhibit NL, is that they have added the curves for 404, and I find these curves to be somewhat similar to what Dr. Grant showed in the sense that the 404 peaks are on the average about four times higher than the 450, and as I explained earlier, that would be expected with four times as much heat generated, because there is four times as much aluminum in the 404 than there is in the 450.

Now, if that was a -- if some of these curves were oxidation reactions, then the curves for the 450 and the Exotec, particularly the 450 in air, that one in particular, since the oxidation reaction if it existed, would provide a lot more heat than the intermetallic reaction, I would expect the temperature rise from the 450 in air to be very much higher, in fact, comparable to the height of the 404 curves, because I would expect about four times as much heat generated, from the aluminum burning, if it were burning.

Now, I also consider that the steeper increase of the 404 curves here as part of the more violent reaction that goes with the higher amount of aluminum reacting with the nickel.

And also all of the curves, whether in air or not, generally are increasing at almost the same period of time, within the accuracy of the test which corresponds to almost the melting point of the aluminum.

Now, if there were burning taking place with those real fine aluminum particles, the burning would have triggered

at a lower temperature, even lower than is plotted on this curve (indicating).

Or if it hadn't triggered by the time it melted, then the burning reaction would then occur at a higher temperature. So in neither case then has that occurred here, the reaction has occurred just at the melting point of the aluminum in each case, whether in air or not. So I think that is indicative of it being the same type of reaction.

(Continued on next page.)

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Q During your cross examination you testified that the error as set forth in the publication, exhibit IV wasn't more than about 10 percent, but at that time you were not allowed to point out the publication in which this error was reported, this degree of error, and would you do this now for the record, and I refer to IW and IX, which is IW at page 815 and IX at page 51?

A Yes. Exhibit IW, the Kubaschewski article in the Faraday Society paper in which he comments on the difference between his results being 10 percent or less than those of Olsen's method, and says that is just within the claimed accuracy of Olsen's method, and exhibit IW --

THE COURT: I think you just mentioned that IW.

THE WITNESS: I am sorry. IX.

A (Continuing) -- are pages of the book by Kubaschewski in which he uses not only his own data but collects others.

And on page 51 at the top he says within an error of about 5 to 10 percent Olsen's results are generally reliable.

So he tends to use the percentage error as a better way of stating it than certain fixed plus or minus so many

calories.

Q Dr. Ingham, you were questioned concerning a so-called discredited phase diagram in exhibit IV.

In your opinion does this phase diagram reflect any way on the work of the authors as reported in this exhibit?

A I reviewed that. I believe that IV is the German article by Olsen. He has a phase diagram in that was mentioned during my cross-examination. That phase diagram isn't dated at all. He simply refers to borrowing that diagram from somebody else, and it happens to be an older diagram of Hansen's that he borrowed.

So that there is no reflection on Olsen's work if that diagram was subsequently corrected.

Q What did Olsen's work report?

A Olsen's work was on the measurements of the heat, and he was not making the measurements of phase diagrams.

Q Now, I would like you to refer to the 515 patent in column 3 running from lines 40 to 56 where reference is made to this 3,000 calories per gram atom.

According to your understanding how is that referenced?

A It is my understanding that the 3,000 calories be used as a guideline.

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THE COURT: As I say, I would sustain the objection to the extent that the testimony is sought in some way to explain in a different way what is meant by the patent, what the patent says.

I will repeat that I will permit you to ask this witness, if he qualifies as one skilled in the art, to explain that he reading this patent would take it to be referenced, as you say, to a room temperature standard. Is that correct?

MR. SPRUNG: That is correct. I did not want to lead him.

THE COURT: Well, look, I would say --

Q Do you understand the question that the Court

posed?

A Yes. I agree.

Q Dr. Ingham, during your cross-examination you were questioned about the phase diagram as shown in plaintiff's exhibit 66-A.

What is your understanding from this phase diagram of the areas marked alpha, alpha prime, beta and the like?

A Those are simply different areas of different phases, different crystal structures of the inter-metallic compounds of nickel aluminide.

Q Now, take specifically the portion marked alpha.

Would you consider that or would you not consider that to be a phase of your nickel aluminide inter-metallic compound?

A I would consider it to be such a phase.

Q Now, during your cross-examination you were questioned as to the illumination of the nickel phosphorous examples 5 and 11 from application 343705?

A I don't have that serial number here.

I assume you mean the one filed in 1964.

MR. SPRUNG: Yes.

MR. CALIMAFDE: He doesn't mean that.

MR. SPRUNG: What is that?

MR. CALIMAFDE: He is asking -- he assumes you mean the one filed in 1964.

MR. SPRUNG: Yes that is the one I do mean. You were questioning why they were eliminated from that application.

THE COURT: Will somebody enlighten the Court as to what we are talking about.

MR. SPRUNG: Well, your Honor, why the examples don't appear in application 343705. That was one filed in February, February 10th, 1964.

Q Now, these examples left out of this application because of the Gutzeit patent?

A No, they were --

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Q Do you have knowledge as to why the nickel phosphorous examples, 5 and 11, were not included in applications 343, 705?

THE COURT: That simply calls for a yes or no answer. Do you have knowledge?

THE WITNESS: Yes.

THE COURT: You do have knowledge? All right.

Q Would you explain to the Court why these examples were not included?

THE COURT: Well, now, that isn't -- no, you asked him to state what he claims to be his knowledge.

MR. SPRUNG: Yes.

THE COURT: Let's explore that.

Q All right, what do you claim -- What is the basis of your knowledge as to why these examples were eliminated?

A The basis of the knowledge is the subject matter that each of the chain of patents involved, the earlier filing patents were broad, covering a lot of material combinations, that -- and included examples -- nickel-clad diamonds for instance I think was in there -- a lot of combinations that were -- or had nothing to do with the application that was filed in 1964. And in the 1964 filing that patent was on the metal combinations which were -- would react exothermically, so at that time a large number of examples were eliminated which were not metals which react exothermically. And nickel phosphorous fell into that area.

Also the patent was being narrowed down too and directed primarily for bonding, and nickel phosphorous does not help bonding.

Q Were the nickel phosphorous examples included, or the nickel application to your knowledge included in any issue patent?

A I believe those examples 5 and 11 that we are talking about are in the patent which issued from a 1961 --

Q That's 3, 254, 970? That I will tell you was the patent that issued on the second filed application,

134, 544 --

A Yes.

Q -- of August 16th?

A That would be the one.

THE COURT: This is a patent not involved here --

MR. SPRUNG: Yes.

* * *

Q In your opinion, Dr. Ingham, is the coating produced by the Gutzeit patent, the nickel phosphorous coating, the end product, is that an inter-metallic compound?

A It is not formed of two metals, but --

Q That's not my question.

A -- in the broad -- in the broad sense they use the word inter-metallic occasionally on that.

Q They being Gutzeit?

A Yes sir.

Q You mentioned in connection with the phase diagram that the phase identified in the diagram as alpha -- Is that alpha nickel or is it alpha or nickel?

You indicated that such region in your opinion, or such phase in your opinion can be considered as including nickel aluminide, is that correct?

A Yes.

Q Do you have any authority on which to base that opinion?

A The concept of the heated of reaction, and my knowledge of physics and chemistry.

Q Is there any written document, any treatise, any textbook, any authoritative work to support that opinion?

A I think these things are called aluminide.

Q Can you answer my question, sir?

A I refer to the Avco product, for example.

Q Can you answer my question, sir?

MR. SPRUNG: He referred to the Avco products.

Q Is there any -- The Avco product identifies a certain product, certain powder as nickel aluminide?

A Yes.

Q My question to you is whether any authoritative

work, treatise, textbook, publication refers to the phase diagram which is identified as alpha and characterizes that region as including nickel aluminide?

MR. SPRUNG: I object. Obviously he hasn't done any research. Do you want him to look up and find, discovery?

I mean does he know offhand, can he site offhand on the stand any such publication? Or does he know of any publication?

THE COURT: Well, let me ask you this: Are we zeroing in specifically now as to whether he knows of any authority --

MR. CALIMAFDE: Any authority.

THE COURT: -- where --

MR. CALIMAFDE: To support his opinion.

THE COURT: -- a phase diagram analysis has been made which reveals the presence of nickel aluminide in the so-called alpha phase; is that the question?

MR. CALIMAFDE: I went broader and asked whether apart from any examination or analysis, whether he knows of any authoritative work that refers to this area in the phase diagram called alpha as including nickel aluminide, to support

your opinion?

THE COURT: So it's really, I take it, not so much what authority but does he know of any authority?

MR. CALIMAFDE: That's right.

THE COURT: Is that it?

Do you, doctor?

THE WITNESS: I have recollections of seeing such referencing, but I can't recall, sitting here, where.

Q All right. You referred to calculations in connection with determining the amount of oxygen that was required in the atmosphere and in the component parts to produce the exothermic reaction such as shown in exhibit PX-88. Did you make mathematical calculations?

A Yes.

Q Do you have them with you?

A Yes.

Q May I see them? Thank you.

I believe at the close of the last session, although I cannot find it in the transcript, a question was asked of the Court by you with regard to the nickel aluminide alloy bond layer between the coating and a substrate, and my recollection of the question was whether this is something

that is photographable, if you wish, and --

MR. SPRUNG: I don't recall anything on redirect concerning anything of an alloy bond --

MR. CALIMAFDE: This was in connection with your redirect examination, where I --

Q Well, let me ask the question: Is this bond, this alloy bond layer between the nickel aluminide and the substrate -- is that identifiable, photographable?

MR. SPRUNG: Between what material and what material?

MR. CALIMAFDE: I just said nickel aluminide and the substrate material.

THE WITNESS: It -- it has been identified.

MR. SPRUNG: I still object that this is beyond the scope of redirect. I don't recall asking any questions or having any questions on an alloy, and I believe this occurred during your cross-examination.

THE COURT: Well, I remember some questions about, I suppose I could say now, the structure, physical structure of the coating in relation to the substrate.

MR. CALIMAFDE: Yes sir.

THE COURT: As a matter of fact it seems to

me there was some photograph which I recall in xerox form that was referred to in that connection.

MR. CALIMAFDE: That's what I was about to ask the witness, whether this photograph in PX-40 --

THE COURT: That's exactly what I --

MR. SPRUNG: I still object. This occurred during his cross-examination. It has nothing to do with redirect examination, and his recross has to be limited to my redirect. He can't go back to what he asked on cross.

MR. CALIMAFDE: I believe this came up in redirect.

MR. SPRUNG: It didn't.

MR. CALIMAFDE: If I'm wrong then I'll withdraw the question, but I think it came up in redirect.

MR. SPRUNG: Well, I'm objecting now. I know what I asked him on --

THE COURT: Well, let me see. Well, I take it from your redirect, Mr. Sprung, that you did explore, if one can call it that -- the issue of the presence or non-presence of nickel aluminide?

MR. SPRUNG: Of nickel aluminide. But the alloy layer --

MR. CALIMAFDE: Nickel aluminide, yes.

MR. SPRUNG: Nickel aluminide. But this alloy layer was gone into on cross-examination.

THE COURT: Yes.

MR. SPRUNG: And it was not gone into in redirect.

THE COURT: But still there were some questions also with regard to sprayed --

MR. SPRUNG: Only the coating itself, nothing about the phase between the coating and the base --

THE COURT: Well --

MR. SPRUNG: -- which this is going into.

THE COURT: But you did go into these matters on redirect with respect to those two exhibits, 66-A and 88.

MR. SPRUNG: Yes.

THE COURT: Is this directed to those exhibits?

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MR. CALIMAFDE: Only in an indirect way, sir. They are directed more specifically to the nickel aluminide -- the so-called bond alloy layer between the nickel aluminide and the substrate.

MR. SPRUNG: And that was not gone into by me on --

MR. CALIMAFDE: Well, then we have a disagreement as to whether it did or it did not. If it did not then --

THE COURT: Well, I'm going to permit Mr. Calimafde to pursue that with respect to this matter of nickel aluminide in the alloy bond layer.

Now getting back to the question which I thought initiated all this, whether it was a photographable presence or not, I don't know what the witness' answer -- I don't think the witness has answered that question.

MR. CALIMAFDE: I believe he said yes, it was an identifiable, photographable alloy bond layer.

THE WITNESS: There has been such a thing identified.

Q I show you PX-40, an article --

THE COURT: Does that mean photographically identified, is that right?

THE WITNESS: Yes.

Q I show you PX-40, an article by Dittrich, on which on page 493 in the lower right-hand corner there is a photograph identified --

THE COURT: What was the page of the exhibit again?

MR. CALIMAFDE: 493, sir.

THE COURT: Page 493, all right.

Q -- which states that the narrow zone between the applied coating and the substrate is the alloy bond layer. Have you ever seen this photograph before?

A Yes.

Q Is the photograph what it purports to be, a photograph of the alloy bond layer between the coating and the substrate?

THE COURT: I'm lost. I've got plaintiff's exhibit 43.

MR. CALIMAFDE: 40. Oh, it's page 493, exhibit 40.

THE COURT: Exhibit 40, 493. I see, yes.

THE WITNESS: I'm not clear as to the question. You're asking me whether in my opinion

it is a good piece of work and correct, or in your -- It says what it says here.

Q Have you ever seen this photograph previously?

A Yes.

Q On your redirect there was some question with regard to plasma spray, bond strength and materials capable of being plasma sprayed. I show you plaintiff's exhibit 90 marked for identification, entitled "The Metco Flame Spraying Processes." At page --

MR. SPRUNG: I object. Again the only questions asked were whether in an exhibit brought out on cross-examination -- what were the bond strengths referred to, and now we are going into a new exhibit on something else.

MR. CALIMAFDE: I beg your pardon, you elicited testimony to the effect that the bond coating produced by plasma sprays was not necessarily a metallurgical bond, and now I am offering his own bulletin, a Metco bulletin, which at page 12 --

MR. SPRUNG: I would like to see where in the redirect examination these questions that provide a basis for recross are coming up.

MR. CALIMAFDE: I don't think there will be any question about this aspect of it, because

there was substantial time spent by you in your redirect on the bond strength produced by plasma spray, and the testimony that was offered was that the bond strength was not necessarily due to the metallurgical bonding layer.

MR. SPRUNG: I have no recollection of such testimony. I recall that you asked him on cross wasn't that so, and he said no, but it was not brought out on redirect or gone into on redirect.

Q Let me ask this --

MR. SPRUNG: Well, I object to the question as being beyond the scope. We have to have some end to these things.

MR. CALIMAFDE: I agree with you.

Q Let me find out first whether this is a bulletin which you identified --

MR. SPRUNG: I don't want you to find out first. I have an objection.

MR. CALIMAFDE: Let me ask a question regarding the bulletin.

Q Is that bulletin offered by Metco --

MR. SPRUNG: I object to the bulleti be-cause it has nothing to do with the redirect

examination.

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MR. KRAMER: Yes, Exhibit DX.

DQ, which was not objected to, is a series of cards kept at Eutectic by Mr. Broderick, indicating various powders, when they came into Eutectic, and specifically various Metco powders. Exhibit DR tends to confirm the lists DQ in that the date of the purchase requisition for Metco 14-E, 11/27/67, corresponding to the date very closely, and the Broderick notes, Exhibit DQ of 11/28/67.

MR. CALIMAFDE: I do not understand if there is any dispute as to the dates appearing on DQ.

* * *

BY MR. CALIMAFDE:

Q Dr. Grant, in your opinion, is there -- is there any difference between a chemical bond or a metallurgical bond in the context of flame-spray coating materials?

A No.

For a chemical bond to take place, you have to have a transfer of electrons. You have to have an inter-reaction between the two for alloying. You have to have a transfer of electrons -- an inter-reaction between the two.

In fine-grain semantics, you can describe it any way you want. They essentially mean the same.

* * *

Q This is the pattern, Defendant's Exhibit LG, made by Dr. Post.

Can you interpret it?

A Yes, sir.

Q If a nickel-aluminide existed in a material, would a pattern reveal its existence?

A It should, if it's there in enough quantity -- it should, yes.

Q Where in the pattern would it appear?

Are there specific signposts or landmarks where one would look for it?

A Yes, the $NiAl_3$ phase has been indexed so the intensities of lines and positions of lines in an X-ray diffraction pattern will appear at specific points in this diffraction pattern.

These positions at particular angles and intensities,

should match up with an indexed pattern for that particular phase if it is there in sufficient quantity.

Q Let me be sure if I understand your testimony.

The X-ray diffraction pattern has lines -- wiggles that go from one extent to the other.

Is it your testimony that at certain angles you can look for this nickel-aluminide, if it exists?

A Yes, sir.

Q These are identifiable and known angles where one would look?

A Yes, sir.

Q Now, if it does exist at these signposts, will it also exist at the same intensity, or does it vary in intensity at these signposts?

A Each different plane reflects a different intensity if there is no preferred orientation, or if there is -- or properly if it's a finely crystalline material, it will show the relative patterns that are repsoducible.

Q From Dr. Post's pattern, can you tell from what range he explored or observed?

A Yes.

He specifically covers the range from about 18 degrees to about 99 degrees, which is documented on Exhibit LG.

Q If the nickel-aluminide exists, at what angles

would it appear most strongly?

A Well, there should be -- the strongest one, which is relatively 100 percent in intensity at the reference point should be occurring on this pattern at about 43.6 degrees to Theta. That unfortunately happens to be covered by a nickel-refraction, so it's not visible in the pattern.

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Q What would be the next most intense location?

A Well, there are 1, 2, 3 patterns which have relative intensities of 70 percent which are limited as medium strong lines. These should occur at 51.1 degrees and that again is interfered by a nickel reflection, but there should be two strong lines at 70 percent intensity at 142 degrees and at 147 degrees which is not on Dr. Post's pattern.

Q Now, at the lower degrees which do appear on Dr. Post's pattern, you indicate that the existence -- or if nickel aluminide does exist, it's obscured by something else -- by what?

A By any solid solution which has the same pattern. It is a phase centered cubic pattern which is shown in that phase pattern. The NiAl3 phase is an ordered phase centered cubic structure. Therefore, the reflection for both phase centered cubic patterns will tend to appear in similar phases, except for the difference due to the order.

Q Is it your testimony that at those two particular locations, you cannot tell whether the nickel aluminide exists?

A Which two?

Q The lower angles, 43.6 and 51.1?

A That's right. They are interfered with by the nickel pattern.

Q Looking at those angles, they tell us nothing with regards to the existence of nickel aluminide?

A You can't pick them out.

Q The next strongest would be 142 and 147 degrees?

A Yes.

Q Those angles do not appear on Dr. Post's patterns?

A No, sir.

Dr. Post testified that had he had time he would have chosen to go to those higher angles, because they do offer a better opportunity for picking out the Ni3Al lines, but these are not in his pattern so there is no way to see that they were there.

Q From your experience, how much more time would it have taken him to go out to those angles?

A Not very much.

His angular spread, I believe, is listed as 1 degree per minute, so that would have meant perhaps 50 degrees -- 50 minutes at that rate.

Q Dr. Post testified that his x-ray diffraction patterns indicates at points 1 and 2 -- you see the circled numerals 1 and 2?

A Yes.

Q -- indicates the existence of nickel aluminide at those points?

What is your opinion, sir?

A Well, these are supposedly 40 percent intensity peaks, both at the 24.75 to theta position which is number 1 and also at 35.2 to theta, which is also 40 percent intensity line and as far as I am concerned this is within the intensity of the background peak and not a differential, nor capable of being used strictly as those two peaks. There are 11 identified patterns -- 11 reflections which can be looked at. Many of them stronger reflections than these and if the 70 don't show up, then it is very very difficult to suspect that these would indicate the presence of Ni3Al. It would be pure guesswork.

Q What in your opinion would be the minimum of points for identifying any nickel aluminide if it exists?

A I don't think it would be answerable that way. It would be answered in terms of intensity of the peaks. One would certainly expect that one would look for the higher intensity peaks -- the 70 percent intensity, if one wants positive identification of those.

In the absence of 70 intensity, if one uses 40 percent, then of course this makes it very very difficult to be able to identify these in a positive manner.

Q Is it your opinion that one cannot identify positively the existence of nickel aluminide in Dr. Post's

diffraction pattern --

MR. SPRUNG: Objection, as leading.

THE COURT: Well, I will sustain it as to form.

Q Does the diffraction pattern produced by Dr. Post contain a sufficient number of points where the nickel aluminide would exist for you to give an opinion as to whether or not it does exist on the sample which underwent analysis?

A My judgment is it is not there in sufficient quantity to be identified by those lines.

Q Had you conducted an x-ray diffraction of the same sample that Dr. Post has analyzed?

A Yes, sir.

MR. CALIMAFDE: Let me put the number 92 on this.

Q I show you a diffraction pattern marked as plaintiff's exhibit number 92 and I ask you if you can identify it?

A Yes, this was a pattern which was run at MIT on the same sample as Dr. Post -- which Dr. Post used, which was done on a Norelco diffractometer and was run from about 18 degrees out to about 150 degrees to theta position. It does include the higher angle portions beyond 98, 99, 100.

MR. SPRUNG: I object to his testifying

to the exhibit until it is established that this witness had run those, so he can be properly cross-examined on them. He said it was run at MIT.

THE WITNESS: Yes, I was present.

MR. SPRUNG: Did you run -- I would like to conduct a voir dire, if I may?

MR. CALIMAFDE: Let me --

THE COURT: Mr. Sprung, I really do believe in this case that at this juncture the interests of the Court would better be served if you would reserve any voir dire for cross-examination. On the basis of Dr. Grant's testimony and on my general perception of what this case is all about, I have to say that I cannot see any basis for any real strenuous objection to this testimony.

MR. SPRUNG: Your Honor, I have been told by my own crystallographer that it is very very critical in running these scans as to the alignment, picking filters and doing all sorts of operations.

* * *

BY MR. CALIMAFDE:

Q Did your examination include those angles where the nickel aluminide lines would appear most prominently, if the nickel aluminide existed?

A Yes.

By going beyond about 100 degrees to theta, we covered three additional NiAl3 possible reflections.

One of these is a very low intensity peak at only 20 percent and is therefore insignificant and the other two then are 70 percent intensity peaks, which according to the charts should appear at 142 degrees to theta and 147 degrees to theta and both are listed as medium strong lines, whereas the 40 degrees are listed as weak lines.

Q So that we all understand what that means, Dr. Grant:

When you say that there appears a medium strong line, that would be a line that should appear medium strong if the material exists?

In other words, the confusion in my mind when you refer to a line as being medium strong is that you have detected the nickel aluminide and it appears medium strong or does your testimony mean that if it exists it should appear with medium strong strength at that angle?

A The way you establish this is by taking pure NiAl3 in powder form. This is subjected to the same kind of diffraction study and from this one establishes a pattern specifically for that inter-metallic phase independent of anything else. On the basis of this, if your sample preparation is correct so

you do not have preferred orientation crystalline, then you will get a distribution of lines as you see in these patterns for that particular material.

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A (Continuing) One then assumes that that same random distribution of the $NiAl_3$ phase, if it exists, would have those same relative intensities on this pattern when it is superimposed against many other things that are there, such as nickel solid solution, such as nickel oxide, such as aluminum oxide, such as the Spinnell $NiOAl_3$, each of them has its own patent and for each of them it has been worked out their own unique patent. The relative intensity and position of the line worked out. When I say "Medium strong" I am saying "Medium strong" relative to the strongest line, which is one of those obscured.

* * *

Q Based on your analysis, what did you find at those lines which are the high intensity lines?

A The one at 142 degrees was again covered by a nickel reflection which happens to be the broadly distorted nickel reflection and therefore incapable of being differentiated and the one that should exist at 147 degrees is not identifiable as Ni3Al reflection.

Q When you say it is not identifiable, what do you mean?

A I do not see anything resembling a 70 percent intensity peak for this particular pattern, if it is matched up with the other.

Q Based on your analysis, in your opinion is there any nickel aluminide present in the sample?

A No, sir.

Q Did your analysis detect aluminum oxide, Al_2O_3?

A Yes, sir.

Q Now, if the aluminum oxide and the nickel aluminide both coexisted in this sample, which would appear more prominently in the analysis?

A That would depend on the quantity and the relative density of the two materials. The Ni3Al is more dense, it would take more aluminum oxide to be discernible by this kind

ofdiffraction technique than the Ni3Al.

Q Did your analysis detect aluminum oxide?

A There appears to be the presence of aluminum oxide.

Q Could you draw any conclusion from the fact that you could detect aluminum oxide, but not nickel aluminide?

A Which means in that case the nickel aluminide would have to be there in significantly smaller quantities.

Q Now, Dr. Post stated in his testimony that nickel aluminide in solution -- I beg your pardon -- nickel and aluminum in solution and nickel aluminide were all about the same.

Do you have an opinion as to the similarities differences between nickel aluminide and nickel and aluminum in solution?

A If so stated, I never heard a more gross error, because the phase diagram flatly says that the nickel aluminum solid solution is readily identifiable as a nickel aluminum solid solution and the Ni3Al is readily identifiable as an intermetallic Ni3Al. The NiAl is a separate phase and is also identifiable and they are distinctly different and identifiable as distinctly different phases.

Q Are you aware of any authoritative work, Dr. Grant, which suggest that there is any nickel aluminide in the phase identified as the Alpha phase in the nickel-

aluminum phase diagram?

A No, sir.

Q In your opinion --

A That is strictly the nickel-aluminum solid solution.

* * *

Q Doctor, is the phase diagram, Exhibit 66A -- may the phase diagram be used in the interpretation of, for example, X-Ray analysis with regard to the flame spraying of metals?

A It's the primary source for all reference material.

Q Is it a valid reference source with regard to analyzing the composition in a flame sprayed coating?

A Yes.

Q If a powder contains 95 percent nickel and 5 percent aluminum, can you tell from this phase diagram what the coating is -- what the nature of the coating would be?

A If the particles are 95 percent nickel, and 5 percent aluminum when it comes down to room termperature it will be 95/5 material and the important difference will be that probably the grain size of the material will be larger --

Q If the 95/5 particle had the aluminum on the outside and was subjected to a flame sprayed environment such as the flame spray on fine aluminum particles -- would the rapidly cooled particle appear?

A Would still have to appear --

Q Is that opinion confirmed by your X-ray diffrac and Dr. Post's diffraction analysis?

A Yes.

Q Have you used argon gas in your teaching and consulting work?

A Extensively.

Q Does it contain oxygen as an impurity?

A Yes.

Q Have you used hydrogen gas?

A Yes.

Q Does that contain a content of oxygen as an impurity?

A Yes.

(continued on next page)

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Q You were present during the testimony regarding the heating of the agglomerated powders identified in Exhibit PX 88, for example the 450 in argon, the 404 in argon, and so forth? Were you not, sir?

A Yes, sir.

Q You were present? Now, is there a technical or scientific explanation for what appears to be a similar rise from PX 38 of the 404 in argon and the 404 in air, but that the temperature of the 404 in air being lower than the 404 in argon, which presumably has less oxygen in it -- in other words, you'd expect the temperature of the powder in air to be higher --

A Yes.

Q (Continuing) -- than you would for the same powder heated in an argon atmosphere?

Is there a technical or scientific explanation why the 404 in argon is a higher temperature than the 404 in air?

A Yes. There -- first of all, these are --

MR.SPRUNG: It hasn't been established that there is a higher temperature.

MR. CALIMAFDE: Temperature difference. A temperature difference.

MR. SPRUNG: That was -- That there is a temperature difference? It was miscalculated.

MR. CALIMAFDE: No, here is the 404 in air, which is there.

MR. SPRUNG: No, it was miscalculated. The two of them are about the same. You miscalculated it, that's all.

MR. CALIMAFDE: No, these diagrams have 404 in air at this point and 404 in argon, taking Ingham's calculations, at this point (indicating). So you have these two, with argon being at the higher peak.

MR. SPRUNG: Look, that's just a miscalculation. Dr. Ingham testified that the curves were plotted wrong.

MR. CALIMAFDE: I'm taking his revision.

MR. SPRUNG: All right, his revision shows that the air in argon is about the same.

MR. CALIMAFDE: No, his revision shows that the peak temperature in argon is at this point. Here is 404 in air. Well, and you can take any other. If there is a question about that, take 450 in argon --

MR. SPRUNG: No, we are talking about -- let's get this straight --

MR. CALIMAFDE: 404.

MR. SPRUNG: 404 in argon is the black, and here is 404 in air. So the two are the same.

MR. CALIMAFDE: No, they are not the same. The argon is higher.

MR. SPRUNG: Where, from what to what?

MR. CALIMAFDE: From here to here (indicating).

MR. SPRUNG: O.K., a fraction of a degree. All right. You weren't talking about that, you were talking about the lower curve.

MR. CALIMAFDE: I was, you are quite right, and I'm still not certain about accepting what you're saying that this curve is 404 in argon.

MR. SPRUNG: Well, let's establish --

MR. CALIMAFDE: That will be significant, because we are either saying -- If ycu are correct, one is higher --

MR. SPRUNG: They are about the same, within a measurable limit.

Q All right, can you explain why they are the same for the conditions where one is heated in air and the other in argon?

A May I say first that I plotted these curves, I plotted them for Mr. Ingham's data. The best data that were available

the curves, were not supplied to us. As a result I had to try to calculate these myself, and I did the best job that I could.

Now, at this stage of the game, not having re-examined the data, I don't know that his new peak is justifiably correct either.

Q Well, assuming it is.

A Assuming that it is, I still feel that there is an explanation not only between argon and air but also hydrogen, which also happens to be higher than the other two, and the answer is that these are commercial powders, they are not at all reproducible in fine terminology. When packed into a crucible for reaction they are not uniformly repacked.

Secondly, the air, insofar as I know from the test data provided by Dr. Ingham, is for a stagnant air atmosphere. It's for an argon and hydrogen atmosphere in motion, which means that the penetration of the argon and hydrogen into the powder mass is capable of being that much greater.

So if you take into account adsorbed gases in the system, which were not removed, if you take into account the impurities in the argon and in the hydrogen, and if you take into account the presence of nickel oxide in these materials, then it is very easy to get these large variations, which are not reproducible or predictable in terms of that kind of experimental

effort.

Q Dr. Ingham testified that seven percent of oxygen was required to burn aluminum. What is your opinion in regard to the minimum amount of oxygen needed to burn aluminum?

A It doesn't take any more oxygen to burn aluminum -- Rather, sorry, it takes only as much aluminum as there is oxygen present for burning. Once burned, the bigger concern is really with the amount of heat which is generated, rather than with the amount of oxygen which is necessary to burn five percent of aluminum.

And I have made a calculation which indicates -- and I can reproduce this on the board if so desired -- which shows that the presence of about 3.5 percent oxygen, which is the amount of oxygen in the nickel powder mass -- that that will take .3 percent of aluminum, that will burn .3 percent of aluminum.

The net result of this is that it will produce .7 percent of aluminum oxide.

If one then calculates the amount of heat which this burning reaction, the heat of oxidation which will occur, to burn .7 percent, to form 7 percent aluminum oxide, it will produce 120 degrees Centigrade increase in temperature, which is of the order of magnitude found in these curves.

I can reproduce that data on the curves -- on the wall,

if you wish, on the board.

Q You made those calculations, and you are --

A Yes, sir.

* * *

Q Now, you mentioned the oxygen in the powder.

From your experience is there also an oxygen content or a water

vapor content in the furnace?

A There is always an adsorbed layer of gas on every material, of both oxygen and water vapor.

Q Now, from your experience, Doctor, can you state whether those potential sources of oxygen are sufficient to produce the amount of exothermic heat which appears in the charts PX 88 and DXML?

A Yes. And I have the calculations to show it.

Q Now, Dr. Ingham also testified that the reaction of the powders as indicated in his Exhibit ML -- that's the shaded area of the exhibit -- if that were exothermic oxidation he said the temperature rise would be significantly greater. Do you have an opinion on that?

A Well, it would be if you burned five percent of aluminum to aluminum oxide. But it takes a very small amount of aluminum to be burnt to aluminum oxide to give you this kind of temperature increase.

Q Now, I previously referred to the 404 in air as compared to the 404 in argon. I could have mentioned the 404 in hydrogen, which is significantly higher.

But let me ask you: The 450, the 450 in argon as compared to the 450 in air, the 450 in argon is shown in red, and where is the 450 in air -- Yes, there is the 450 in air, which is the solid block. Can you see it from where you are,

Dr. Grant?

A Yes.

Q And the 450 in argon is red. Can you explain why the temperature differences between the 450, for example, in argon and air, and the 404 in argon and air, why these substantial differences exist in terms of temperature differences?

A You mean in each lot or --

Q Yes, the 450 as compared to the 404.

A The -- the 450 alloy, of course, since it does not form the inter-metallic phase, will generate its heat from the heat of formation of the oxide. And there is more than enough oxygen present in the system to allow for the small burning necessary even in these atmospheres to gain this kind of a temperature increase.

On top of that, if you compare that then to the 404-type material, then the 404 material has in addition the exothermic heat of reaction of the formation of the inter-metallic compound, which will add heat to the heat of oxidation that occurs thereto.

Because the variations in each of the lots then depends on the experimental techniques and on the variations in powders from lot to lot, the packing and the general run of the experiment. This is not unusual.

Q In terms of the significant heat which is important,

the peak of the temperature rise or the difference in the temperature rise in the area of the curve?

A Well, if you are going to compare the total heat output, then it is not just the temperature peak, it has to be the area under the curve -- this is a time -- temperature times time proposition -- in order to get the total heat content.

Q And from your tests would you compare the area under the curve in the 404 as compared to the area under the curve in the 450?

A In terms of the atom percent -- that is the 80/20 and the 95/5 -- if they are compared on an atomic basis, which is the way materials react -- they react on the basis of the number of atoms -- then in the 80/20 composition, which is 35 atom percent, and in the 95/5, which is 10 atom percent, the difference in aluminum content between the 80/20 and the 95/5 is 3-1/2 to one, whereas I measured the areas of the curves in the 450 and the 404, and that difference is less than two to one.

So that if in fact one were going to base this strictly on aluminum content, then the heat content generated by the 404 should have been at least twice as much as it is. In other words, the area under that curve should have been twice as large.

It isn't, which similarly says that the heat which is

being generated by the 450 material is larger in proportion to the amount of aluminum it contains by far, by the factor of two to one, compared to the amount of heat which is generated by the 80/20 404.

Again, it's almost four times as much aluminum in the 404 than the 450, but it generates only slightly more than twice as much heat.

(Continued on next page.)

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Q Are these curves significant from the viewpoint of telling us anything in regard to the exothermic reaction?

First in regard to the nature of the exothermic reaction, as to whether it's inter-metallic or oxidation?

A No, it would be very difficult to tell from those curves.

Q Are they significant from the viewpoint of telling us heat is being generated by one powder compared to the other, in terms of 450 versus 404?

A Yes sir.

Q These curves -- and that's what you just explained -- are in terms of areas to peak?

A Right.

Q What is the significance of the peak, or the differences in peaks, for these various curves?

A The peak temperatures?

Q The peak temperatures, yes?

A Only in the sense of telling you how -- how rapidly perhaps the reactions went once they started in -- in building up to a temperature maximum.

Q Now, in this curve PX-88, in the 404 powder there appears to be a dip below the base line. Is there a significance in that dip?

A Yes, sir. It -- it indicates that there was a delay

of up to almost two minutes before the 404 powder began to react.

Now if, if instead of looking at this chart, if one looks at the numerical charts and the curves that were provided by Dr. Ingham, then there it's very clear that those reactions are delayed and take place at a later time. In other words, they don't initiate nearly as quickly as the 450 type does.

Q Is it --

A And the delay is at two minutes, and the reaction starts at a higher temperature. That's very clear in the charts.

Q The strip charts?

A Yes sir.

Q What is the significance of that, doctor?

A Which suggest that the nature of the reaction is different from the 404 than it is for the 450.

Q Now, Dr. Ingham superimposed your exhibits 64 and 65. I don't have it before me, but he testified that the rates of heating were the same for PX-64, which is the 95/5 powder, and PX-65, which is the 80/20 powder. These are the two tests, calorimetric tests, that you had conducted at MIT?

A Yes sir.

Q All right, can you tell the rates of heating from the tests you conducted, --

A Well, I --

Q -- PX-64 and 65?

A -- in direct testimony I kept saying over and over again that you cannot get a rate reaction by plotting degrees Centigrade against degrees, and that you would have to get actual times in order to be able to establish rates; that these did not in fact tell you what the rates of heating were.

Q Did you conduct tests which showed the rates of heating?

A Yes sir, as a result of that discussion I did -- then did time these by superimposing a time scale on the curves.

MR. CALIMAFDE: Would you mark these, PX-93, a curve for the 80/20 powder.

THE CLERK: So marked plaintiff's exhibit 93 for identification.

MR. CALIMAFDE: And 94, which is for the Eutectic 95/5.

THE COURT: What's 93 again?

MR. CALIMAFDE: 93 is the 80/20, sir.

THE COURT: 80/20?

MR. CALIMAFDE: And 94 is the accused 95/5

powder.

THE CLERK: So marked plaintiff's exhibit 94 for identification.

Q Let me show you these two curves and ask whether you can identify them?

A Yes sir, these were the same types of calorimetric tests that were in exhibits 63-64, 64-65, whichever it is. Only in this particular case we ran material, and again have exactly the same curves duplicated -- that is the shapes, the fingerprints of the curves are as they were before, so these do in fact turn out to be a consummation of the shapes of the curves we indicated, only now what we did was to superimpose a time scale -- and that's marked on the curves - for the time from the bottom of the curves, where it is molten, to the top of the curve, and that difference, based on this scale, shows that the 95/5, the 95/5 heats at a rate of .6 degrees per second during that interval of time, and the 80/20 heats at .4 degrees per second.

In other words, the 95/5 is heating at a rate 50 percent higher than is the 80/20, which confirms our statement originally that these were two different classes of reactions.

MR. CALIMAFDE: Thank you.

Will you mark this photograph as plaintiff's 63-D.

5 Grant-direct

THE COURT: May I see them?

THE WITNESS: The patterns are the same as before on all the different lots.

THE CLERK: Photos marked plaintiff's 63-D for identification.

Photo marked plaintiff's exhibit 95 for identification.

MR. CALIMAFDE: 63-D is in the book of exhibits, your Honor.

Q Let me show these to you and ask whether you can identify 63-D?

A Yes sir, these were -- these are scanning electron-microscope views of individual 95/5-type particles which had been heated, as had been the calorimetric tests, in a stagnant air atmosphere to a temperature just below the melting point of the aluminum.

And what we see here is the evidence that the carbonized -- that is that's the binder which is originally present there, leaving a fine structure where aluminum particles had been held in place. The aluminum particles have all fallen out, leaving large bare areas of nickel surface which are clearly discernible on -- on the particles.

MR. CALIMAFDE: I think maybe I ought to show this to the Court, since this is a more

readable photograph than what's in your book, your Honor.

THE WITNESS: This is a -- a single powder particle, which is originally the nickel nucleus, with aluminum held in the binder. Now having been heated not to the point where the aluminum melts but only to the point where it's just approaching melting, the aluminum was in these areas which are now simply holes.

The aluminum has simply fallen out of position, leaving large areas here which are completely bare of anything, a binder or of aluminum, which is characteristic of the non-uniform layering of the -- of the coating and the aluminum.

And so we see that none of the aluminum has been held in position by the binder. In other words, the -- the aluminum as it heats, being a much higher conductor than the binder face, gets hot and immediately burns its way out of the binder.

So it tends to separate at a time when there is still a little bit of the binder still left on the nickel, now in a carbonized state.

Q Was the temperature higher, the temperature at

which the binder melts higher than 200 degrees or 300 degrees C?

A Yes sir, higher than that. Higher than the temperature at which the binder begins to evaporate and to melt.

Q And these little pockets indicate what?

A These are the pockets where aluminum had been held in position by the binder.

Q And now would you explain what exhibit 95 is?

A Exhibit 95 is also a scanning electron microscope view at 200 magnifications. This is the same wafer which has been quoted by Metco, and which is exhibit number --

MR. CALIMAFDE: What is that exhibit?

That's that sample of that --

THE WITNESS: The little brown sample.

MR. KRAMER: LF.

Q LF. That's the sample --

A Which is the sample on which Dr. Post then ran his diffraction pattern. It's the same sample I ran my diffraction pattern on.

This is the electron scanning microscope view of that coating, and what is very evident here, now this has gone through the flame gun and has been impinged as a coating on the substrate -- and if you will look, it's very, very clear that the great majority of the nickel particles have not

melted. In fact you can see the corrugated type of surface that is characteristic of that nickel. It has simply not melted. They are simply held in place by small amounts of a liquid ~~face~~ phase, which you see the smooth area is the molten face, and these particles are discretely nickel, which is unreacted with aluminum. The aluminum particles have all disappeared.

Q Can you tell the nature --

THE COURT: What would be the nature of this material?

THE WITNESS: That is an oxide, and we did not identify it as an oxide, but the fluorescence that that gives in the x-ray beam does not permit it -- it to be seen in the same way that the metallic structure is; being a non-conductor, it is an oxide, and we did not trouble to identify it because that would be a very difficult and very long process.

THE COURT: Now, this was an adhering coat -- right?

THE WITNESS: Yes sir. This is an adhering coating. This is -- Is the sample here?

THE COURT: Yes, it would be good.

THE WITNESS: But the reactions are far, far different because of the extreme speed with .

which this happens.

Q Here is the sample?

A That is -- that is considered to be an adherent coating, which we believe it is.

THE COURT: And this was the 95/5 Exotec applied with the Rototec?

THE WITNESS: Yes sir.

THE COURT: And --

THE WITNESS: Looking directly at this surface, this is representative of -- of the coating.

THE COURT: And you say -- and this is not, by way of disputing you -- that what is shown here in the darker areas --

THE WITNESS: These are discrete nickel --

THE COURT: Discrete particles?

THE WITNESS: -- particles which have not been melted.

THE COURT: That the nickel did not melt in this part?

THE WITNESS: No sir, a great majority of the nickel did not reach its melting temperature.

The further identification of this, of course, is the fact that these have the size that

they should be; they are approximately 60 or 70 microns at this magnification.

THE COURT: But there is no question, however, that they are being held firmly to the substrate?

THE WITNESS: Yes sir, there is molten ~~face~~ phase particles melting there.

THE COURT: Yes, of both nickel and aluminum?

THE WITNESS: Nickel and aluminum, yes sir. Yes sir. In solid solution. Which is what all of the x-rays show.

THE COURT: But now although these more visible ones have not melted, indicating that they didn't reach a molten stage --

THE WITNESS: That's right.

THE COURT: -- there is somewhere below those -- and perhaps in this area -- I don't know whether you can say that that is below this --

THE WITNESS: No, that is -- that is on the surface.

THE COURT: So as a matter of fact it is even conceivable that such a layer spreads over the entire surface?

THE WITNESS: One would presume that this layer --

THE COURT: Yes.

THE WITNESS: -- is self-progressive, since one sprays to thicken the coating. Yes sir.

THE COURT: Yes, but your view is that this is what?

THE WITNESS: It is a non -- it is a non-conductor, and therefore an oxide.

THE COURT: An oxide?

THE WITNESS: Yes.

(Continued on next page.)

THE COURT: And you're saying that this is what is in effect the most intimate relationship between the coating and the substrate?

THE WITNESS: Yes, sir. In other words, our X-ray diffraction pattern here says that we see nickel and nickel solid solution, that we see aluminum oxide and that we do not see Ni_3Al. And that is -- in other words, this is a diffraction pattern which is something that terpable in terms of other patterns. This is an actual view of that.

THE COURT: Well, let's see, was this one marked?

MR. CALIMAFDE: Yes, sir.

THE COURT: Let me just make a note of these things so I will refresh my recollection.

MR. CALIMAFDE: For the record, the witness has identified something on the photo of exhibit 95 as aluminum oxide, and that's the part which appears to be whitish in the photograph --

* * *

Q Or melted condition. Can you tell from the photograph what has been melted?

A No, sir, that would have to be identified by other techniques such as an X-ray diffraction technique, in which case the molten phase should appear as one of the phases which is registered on the diffraction pattern.

Q Now, from your diffraction pattern, can you tell whether there is nickel and aluminum in solution?

A Yes, sir.

Q Is there?

A Yes, sir.

Q Can you tell about the amount of nickel and aluminum in solution from the diffraction pattern?

A Yes, you can.

Q Can you tell us?

A Yes, sir. It's -- the -- what we do is to take the most intense peaks for this calculation, and these calculations indicate that there is something approaching 5% aluminum in solution. But the accuracy of that number would not be that great.

* * *

Q Dr. Grant, you testified, going back to the beginning of your testimony about these bonding layers, you said that as far as you were concerned chemical bond or alloy bond was the same thing, is that correct?

A In metallurgy if you use the expression chemical bond it can mean only one thing : Alloy bonds.

Q Only alloy bonds?

A Yes, sir.

Q Chemical bond?

A Yes.

Q You're sure of that?

A Yes, sir, I am very sure of it.

Q And that involves an electronic exchange?

A Yes, sir.

Q And it's a reaction?

A Yes, sir.

Q In other words, when I alloy two metals together I get a chemical reaction.

A Yes, sir.

* * *

Q Now, when nickel aluminide is formed, what you call nickel aluminide --

A I am sorry. There are two of them. Which one do you want to talk about.

Q Let's say Ni3Al. Does the nickel and aluminum react with an electron exchange?

A Yes sir.

Q A chemical reaction?

A Yes sir.

* * *

Q I am not asking you that. I am asking you the time now. The time that the particle is maintained at the temperature in Exhibit 63-D is many, many times larger --

A Yes, sir.

Q -- than the time it would be subject to this temperature in flame spraying?

A Yes, sir.

Q There is much more of a time interval than for a resin to evaporate then?

A Yes, sir.

Q Did you see any aluminum particles on --

A No, sir, I didn't see any aluminum particles.

Q What are the white spots here --

A Aluminum oxide.

Q These are all aluminum oxide?

A Yes, sir.

Q So that you have no --

A No doubts.

Q Are you sure that is not aluminum coated with a little oxide?

A Very sure it is not.

Q Just pure aluminum oxide?

A Yes, sir.

Q And what happened to the other particles where the holes are?

A Burnt out and fell down to the bottom of the --

Q Did you collect them at the bottom?

A Yes, sir.

* * *

Q Assuming the point where the reactions occur, each of the reactions themselves, is there any belt --

A By then the observation reaction --

Q I am not asking you about that. I am asking you once the reactions are initiated is it not true that the 404 reactions proceed at a faster rate than the 450 and Exotec?

A After they get started --

Q Is that true?

A That is what the curve says.

MR. SPRUNG: That is all you were asked.

Q Now, let's get down to your delay in the reaction.

A Yes, sir.

Q Isn't the reaction still faster, the overall reaction, isn't the overall reaction still faster?

A Excuse me. I am not concerned with overall reactions, if we are talking about two different things.

Q Isn't it true the exothermic reaction, even taking the time delay, that the exothermic reaction is faster in the 404?

10 A Yes, sir.

* * *

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Dr. Grant/Cross/Sprung

BY MR. SPRUNG:

Q Dr. Grant, you testified that in the calorimeter test, that the best indication of the amount of heat generated in the exothermic reaction would be the area under the curve; is that correct?

A Depends on which curve.

Q Your own curves.

A No, sir.

Q Wouldn't be --

A That is degrees Centigrade per degree, and therefore does not indicate the total quantity of heat -- a different kind of a measurement.

Q I see.

How would you determine the amount of heat - relative amounts of heat generated under your curves?

A You wouldn't. You would run a different kind of a curve, a temperature time curve.

* * *

MR. SPRUNG: I cannot measure any difference between the reference sample and the sample that he is taking, except by taking an arbitrary point that the witness wants to take.

THE WITNESS: We went through this, trying to get the rates. It took me a long time to convince Mr. Sprung that the test is not equipped to establish a rate structure, no more than I am attempting to get absolute values of a particular calorimetric reaction at this point. If I did, I would have calculated it. What I am showing here is the characteristic behavior patterns between

the two, whether they differ by one or two degrees is unimportant. What I am attempting to do is to establish the nature of the reaction just as has been established in the other calorimetric curves, that they always give you a kind of reference material. They do not in any sense attempt to solve the problems of the world in one curve.

* * *

Q Okay.

That's all I want to say, I don't have to worry to find the temperature at any point. I just look at the horizontal scale --

A It's a differential temperature plot.

Q All I am asking you, if I want to know the temperature at this point, it is the highest point on 94, which is 690?

A Yes, just about.

Q I see.

So therefore, what is the point at which the aluminum starts to melt on 94?

A Somewhere above -- About 580 (indicating).

Q I see.

The temperature is shown on 94, where the aluminum starts to melt --

A On this (indicating).

Q What is the melting point of aluminum?

A 660.

Q And is it not true that you testified that you could determine the accuracy of the instrument by noting the melting point?

A Yes, in the sense they are reproducible over and over again.

Q On your direct, you said, "This instrument has detected it very accurately, the initiation of the melting of aluminum."

A Yes.

Q You indicated that is how you tell the strument is accurate?

A Final melting here is at 60 -- the melting effect is in 60, where the material is fully molten.

Q Would you read this temperature at the lowest?

A 670.

Q Am I correct that that line is at 675?

A I think he is splitting hairs.

Q Would you look where you put the line -- I am not asking where.

A That was just put there to establish the time interval between that point and the point here (indicating).

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Q I see. And that's where it's conceded, and for this, I have 640 -- right?

A Right.

Q So I have the difference between 640 and 675?

A Yes, sir.

Q As indicating the accuracy of your instruments on --

A No, it indicates in part the melting point of the particular aluminum which is being used. Only very, very, very pure aluminum melts at exactly 660 degrees.

Q If you --

A If it's contaminated, or it's commercial aluminum, it will melt at a lower temperature.

Q I'll read your testimony --

A Or begin melting at a lower temperature.

Q It says, "If you look at the lower scale, where the curve dips for the first time, and that is the point where the endothermic reaction occurs, namely, that is a melting reaction, that is exactly the temperature at which pure aluminum melts, namely 660 degrees centigrade, so this instrument has detected very accurately the initiation melting of the aluminum."

A Yes, sir. Yes, sir, for the purposes of this testimony. That is exactly right.

Q I see. So -- But yet, on the one we got 4 --

What was it, 440, and the other, was it ~~540~~ 640, and the other 675?

A Yes, sir, that's close enough.

* * *

Q What do you base your conclusion on that the sample which you analyzed contained no nickel aluminide?

A I couldn't find enough lines to identify Ni3Al.

Q Now, you also were asked a question with regard to the distortion of the --

A Distortion?

Q -- what, the lattice?

A The distortion of the individual reflections.

Q Now, what is the --

MR. SPRUNG: He wasn't asked any questions on the distortion of the lattice.

MR. CALIMAFDE: Well, I imagined it, then.

Q Were you asked a question with regard to the diffraction pattern and the --

A I distinctly recall something about distortions, yes sir, due to the fine grain size and to the --

Q And you answered, as I recall --

A -- particles which are locked in from the -- from the quenching operation.

Q Does the distortion indicate an aluminum in

solution in nickel or a nickel aluminum solution?

A No, because the nickel in solution simply shifts the line, but if there is distortion it simply hides any effect of any solution effect anyway. It tends to obscure it rather than expose it.

Q Does the x-ray diffraction pattern show any nickel and aluminum in solution?

A Yes, it does show some -- some -- some small amount of aluminum in solution.

Q Can you tell from the pattern how much of the nickel aluminum in solution exists?

A Yes you can.

Q Can you -- About how much, can you tell us?

A Well, I found that it was significantly less than 5 percent. It was a small shift in the pattern.

* * *

BY MR. SPRUNG:

Q You testified that you determined there was significantly less than 5% aluminum in the solid solution.

A Yes, sir.

Q How did you make those calculations?

A By line shift.

Q By line shift. Do you have those calculations here?

A No, I don't. Because I didn't attempt to get a precise number on it.

Q What number did you get?

A About 3%, 2 1/2%.

Q About 3%? 3, 3 1/2%?

MR. CALIMAFDE: Of what?

THE WITNESS: Of aluminum in solution.

* * *

THE COURT: Why does it take so much time and trouble to discover something if it is plainly there?

THE WITNESS: Well, if material is present -- We are dealing with a very difficult phase, a phase which resembles at high temperatures -- is indistinguishable from nickel, and at low temperatures, if it orders, and to the extent that it orders, certain new pips develop.

I was just looking at an article by Dr. Grant in which he only observed four peaks or so, very weak ones, and that was, I believe, on pure nickel-aluminide.

It is difficult to observe the peaks in a case like this.

So if the material is present, what we try to do, or even if it is not present, in looking for it, we try to make certain that, A, that the peaks are real and they are above background.

If you ran it slowly -- If I ran it at a quarter degree a minute, I would have gotten four times the intensity per unit of time that I got in my actual scan, and the statistics would have been better.

Now, I would also have re-run it to make sure each of these is reproducible in that same position. I am quite certain it would have been. But certaintude is not the test of certainty, as a lawyer once said, Oliver Wendell Holmes. But I like to do things that way.

It is not that sample. It is not as unambiguous as we were told a few minutes ago, by any means.

It is always the non-crystallographer who finds things clear and unambiguous in crystallography.

There is ambiguity. I like to run things

slowly, and run them repeatedly, until I am very certain it is present, or certain it is not present, or have no opinion.

But I would hesitate to take someone else's chart, run this way, and use this as a basis for anything.

Q Dr. Post, is there any ambiguity as to the distortion of the nickel phase?

A Oh, the big peaks are clearly distorted, that is, the main peaks, due to nickel or nickel-aluminum, whatever one wants to call it.

Those are broadened. And it is my opinion that the broadening is due to stress and strain in the sample because of the residual stress, which is due to something else -- usually something else being present, combined with the suddenness of cooling, which did not give the sample a chance to anneal properly.

Q What would cause that distortion?

A Many things. The presence of impurities like aluminum, and the presence of -- sudden cooling could do it. That is why people cool things slowly.

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(continued on next page.)

Q Let's take your test for a moment or two, as compared to Dr. Grant's. Did your test show an aluminum-oxide?

A Sure.

Q Did Dr. Grant's show an aluminum-oxide?

A Yes. I remember he did mark it.

Q Did your test show an absence of aluminum?

A There are two little pips there which -- one really --

which one might possibly attribute to aluminum. I don't really know. Those I mentioned before that I consider them very, very doubtful.

Q Did Dr. Grant's scan show the probable absence of aluminum?

A It shows no --

Q Doesn't he have a legend on his graph?

A As a matter of fact, he has a place where he says, "Post aluminum." I show a little pip there.

I hate to say this, but if you come over and take a look, I will be glad to show it to you.

Q What is the sensitivity of Dr. Grant's blip, as compared to your blip on the aluminum phase --

A The same thing.

Q So that both of you indicate probably no free aluminum? Both of you indicate the existence of aluminum oxide?

A Yes, but I think the peaks are stronger in my chart.

Q Both of you found, of course, nickel.

A We found a phase which is nickel, with a -- with its peak shifted from the ideal.

I hesitate to draw any conclusions, really, from something which is cooled so abruptly.

This is not the way you prepare a specimen for a careful

precision measurement of the amount of aluminum present.

Q Dr. Grant's scan also included an observation, or a scan, at the end of about 120 degrees, 142 degrees, and 147 degrees, and as we understand your earlier testimony, your scan did not go into that region?

A Let me make that point clear --

Q Well, let's establish the answer first.

A The answer is yes.

Q Let me ask you another question before we get to an explanation.

Do you agree with Dr. Grant that at the higher angle, the intensity line for nickel-aluminide, if it existed, would be a greater intensity line?

A No.

Q You do not agree with that?

A Absolutely not.

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